Annual Convention to be held in Portland, Maine, September 13, 14, and 15, 1916.

Volume 30. Number 1. MARCH, 1916. $3.00 a Year. $1.00 a Number.

JOURNAL

OF THE

New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY

THE NEW ENGLAND WATER WORKS ASSOCIATION,

715 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

Copyright, 1916, by the NEW ENGLAND WATER WORKS ASSOCIATION.

OFFICERS

OF THE

New England Water Works Association

1916.

PRESIDENT.

WILLIAM F. SULLIVAN, Engr. and Supt., Pennichuck Water Works, Nashua, N. H.

VICE-PRESIDENTS.

CALEB M. SAVILLE, Chief Engr., Bd. Water Commissioners, Hartford, Conn.
CARLETON E. DAVIS, Chief, Bureau of Water, Philadelphia, Pa.
SAMUEL E. KILLAM, Supt. Pipe Lines and Reservoirs, Metropolitan Water Works, Boston, Mass.
R. S. LEA, Civil and Hydraulic Engineer, Montreal, Canada.
D. A. HEFFERNAN, Supt. Water Works, Milton, Mass.
WILLIAM W. BRUSH, Deputy Chief Engr., Bureau of Water Supply, New York, N. Y.

SECRETARY.

WILLARD KENT, Civil Engineer, Narragansett Pier, R. I.

EDITOR.

RICHARD K. HALE, Civil Engineer, 85 Water Street, Boston, Mass.

TREASURER.

LEWIS M. BANCROFT, Supt. Water Works, Reading, Mass.

ADVERTISING AGENT.

GEORGE A. KING, Supt. Water Works, Taunton, Mass.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

R. C. P. COGGESHALL, Supt. Water Works, New Bedford, Mass.
ROBERT I. THOMAS, Supt. Water Works, Lowell, Mass.
F. J. GIFFORD, Supt. Water Works, Dedham, Mass.

FINANCE COMMITTEE.

GEORGE H. FINNERAN, Asst. Supt. Water Service, Boston, Mass.
D. N. TOWER, Supt. Water Co., Cohasset, Mass.
JOHN MAYO, Supt. Water Works, Bridgewater, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

Table of Contents.

PAGE

Portrait of William F. Sullivan, President of the New England Water Works Association....., Frontispiece

Leakage from Lead Joints in Cast-Iron Water Pipes. By Arthur H. Smith..... 1

Decolorization of Water by Storage. By Ralph H. Stearns, 20

The Water Supply of Salem and Beverly. By Francis F. Longley..... 35

Improvements to the Water Supply of the City of Fall River. By H. K. Barrows..... 46

Detail Methods Used in the Forestation of Watersheds. By Sidney K. Clapp..... 64

Costs and Results Obtained in Reforestation of the Croton Watershed. By T. C. Culyer..... 69

Double Sand Filtration of Water at South Norwalk, Conn. Removal of Organisms, Tastes and Odors. By Harry W. Clark..... 86

Reasons for Adopting the Solid-Wedge Type of Valve in the Boston Water Department. By George H. Finneran..... 101

Reasons for Using the Double-Disk Type of Valve. By J. M. Diven..... 106

Wire Fences and Concrete Posts. By Ralph N. Wheeler.. 124

Grouting or Cushioning Standpipe Bases. By Charles W. Sherman..... 131

The Wakefield Water Sterilization Plant. By Edward C. Sherman..... 135

Proceedings:

Annual Meeting..... 143

Reports of Officers 150

Presidential Address 160

February Meeting..... 173

Executive Committee:

January 12, 1916..... 180

February 9, 1916..... 181

WILLIAM F. SULLIVAN,

President New England Water Works Association,

1916.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXX. **March, 1916.** **No. 1.**

This Association, as a body, is not responsible for the statements or opinions of any of its members.

LEAKAGE FROM LEAD JOINTS IN CAST-IRON WATER PIPES.

BY ARTHUR H. SMITH, ENGINEER ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES, BOSTON, MASS.

[*Read September 7, 1915.*]

This subject deals with one phase of a "conservation" movement which has for years received careful consideration by many officials and engineers who are responsible for the security and distribution of our public water supplies. During the last few exceedingly dry years prior to the present season, when the margin between available supply and consumption has been rapidly narrowing, special attention has been given to the elimination of waste as a means of increasing this margin. Many towns and cities have found that by systematically reducing the amount of water running to waste, their present supplies could be made ample for their needs. By various systems of metering mains, large leaks have been located and repaired, the installation of meters on house connections has largely stopped unnecessary losses taking place at plumbing fixtures, and appreciable savings have been made. With the development of the pitometer into practicable form, additional impetus has been given to the locating of leaks in mains, and extensive surveys have been made in New York, Philadelphia, Washington, Chicago, Milwaukee, and other cities, the results of which are matters of record.

The studies made have shown very large losses from three principal causes:

(*a*) Leaking of underground mains.
(*b*) Broken or abandoned service pipes.
(*c*) Defective plumbing fixtures.

Of these causes, the third is being corrected quite satisfactorily by metering. The first and second are more difficult to reach. In old systems it frequently happens that large leaks occurring in porous soil, under streams or near sewers, may continue for years without giving any surface indications and thus escape the attention of the unthinking or careless official. Usually it is feasible at some labor and expense to locate and stop these larger wastes, but the smaller leaks occurring at imperfectly made lead joints or at minute cracks in the pipe represent a class of losses generally felt to be incurable. It is more especially with these types of leakage and some observations regarding the amount lost in this way that this paper deals. They rarely cause much concern to the water-works man, although the total volume lost in a year is often very large.

In an effort to determine the volume of leakage from underground mains, some officials have simply subtracted the quantities taken out from those fed into a system, but this has generally not been very successful because of the large number of assumptions or guesses which have to be made. Of course no conclusions, even approximately correct, are possible except where practically 100 per cent. of the service supplied is metered. The best performance along this line which has come to the writer's attention is that in the city of Cleveland, Ohio, where, under the administration of Dr. E. W. Bemis, in 1909, all but 7 per cent. of the supply delivered into the mains was accounted for, a loss equal to only 6.3 gal. per capita per day. The same year the water registrar of Worcester, Mass., reported that all but 19 per cent. or 11.5 gal. per capita of the supplies metered into the mains of that city was accounted for. In the several suburban communities of the Metropolitan District surrounding the city of Boston which are 100 per cent. metered, about 65 per cent. of the supplies entering the systems is metered out or otherwise accounted for. In 1904 Mr. Dexter Brackett, C.E., reported* quite in detail the various forms of waste which were taking place in the city of

*JOURNAL N. E. W. W. A., XVIII, 107 (1904).

Boston and its suburbs. His general conclusion was that from 10 000 to 15 000 gal. per day per mile of pipe were being lost by leakage from the underground mains, which represents a total for the districts served of 15 to 22½ million gallons per day, or 16½ to 25 gal. per capita per day. An interesting suggestion contained in that report as a help in reducing this leakage is that meters of Venturi or Deacon type be installed at favorable points on the city mains so that frequent determinations of losses may be made in prescribed sections.

The general experience of water-works men who have studied this particular phase of leakage seems to be that from 30 to 40 per cent. of the total supply which enters the system is unaccounted for. That is, only 60 to 70 per cent. is delivered for legitimate purposes, the rest being lost as leakage.

In an attempt to determine with some accuracy what is a proper allowance for this incurable waste, Mr. John R. Freeman secured data from several New England cities for his report on the "Water Supply for the City of New York," dated March, 1900, to show the consumption during early morning hours, which was assumed to be made up largely of leakage from mains. On a "gallons per capita per day" basis, these figures were: Fall River, 10; Woonsocket, 8; Boston, 10; Providence, 20; Milton, Mass., 3.

It is not correct to assume that all of the leakage in the instances cited takes place at lead joints and cracked pipe, for there is an appreciable contribution from defective service pipes, hydrant valves, blow-off gates, leaky packing at gate valve stems, etc. While, therefore, the "gallons per capita per day" basis is well adapted to represent the total underground leakage, a more appropriate unit in which to express the leakage at joints seems to be "gallons per day per linear foot of lead joint," and in the cases quoted below, this standard has been used.

In the writer's experience with the Factory Mutual Fire Insurance Companies, questions have frequently arisen between the managers of corporations insured by them and public water-works officials as to what becomes of the water passing from public mains into private fire protection yard systems. In such cases the water-works official is usually well satisfied to install a meter on the main feeder and charge the consumer with the registered

quantity of water, allowing him to use it for whatever purpose he desires, while the attitude of the insurance companies has been that if all domestic and manufacturing water is used from a separate metered line, the interests of the community are not jeopardized by omitting meters from the fire service lines, provided, of course, that these are used solely for this purpose. In other words, the water for extinguishing fire in protected plants should be as freely supplied and with as little obstruction to flow as it would be if taken from street fire hydrants. The arguments on both sides of this proposition are so well known that they will not be repeated.

In one instance, at a risk in Eastern Massachusetts having both high and low service connections with public mains, it was found that considerable quantities of water were escaping from the high-service reservoir, and as this occurred during a dry season when there was a natural shortage of supply, the waterworks officials deemed it expedient to shut off this particular connection, which they did without notification to the corporation. In the study of the situation which followed, the writer found that 11 000 gal. per day were being lost through the underground system, thus representing about 7.3 gal. per day per linear foot of the 1 500 ft. of lead joint involved. As this was deemed excessive, the points of greatest loss were approximately located by meter readings on the various sections into which the system was divided by gate valves, the joints were uncovered in the worst sections, and those found leaking were repaired. By this means, the loss was reduced to about 2 000 gal. per day, or 1.3 gal. per linear foot of joint. The pipes in this instance were 6 in. and 8 in. in diameter, total length 5 500 ft., length of lead joint 1 500 ft., and average pressure 105 lb.

A short time after this experience, a favorable opportunity came for conducting a test for leakage on a small new public waterworks system at Medway, Mass. This work was built by the Hanscom Construction Company of Boston, H. A. Symonds engineer, under the supervision of Mr. Erastus Worthington, C.E., of Dedham, Mass. The sources of supply are driven wells from which water is pumped through the distribution system to a standpipe 30 ft. in diameter by 80 ft. high, whose capacity per foot in height is thus 5 288 gal.

The distribution system is made up of cast-iron pipes 6 in. to 12 in. in diameter, Class E, New England Water Works Association specifications. The lead in the 6-in. sockets is 2 in. deep, and in the 8-in., 10-in., and 12-in. sockets 2½ in. deep. In the following table, the system is analyzed with respect to the lead joints.

TABLE 1.

Cast-Iron Pipe.		Number of Lead Joints.						Linear Feet of Lead Joint.		
		Straight Pipe.								
Size. Inches.	Linear Feet Laid.	12-Ft. Lengths.	Short Lengths	Specials.	Gates.	Hydrants.	Total.	Per Joint.	Total.	Per Foot of Pipe Laid.
12	3 279	274	3	34	5	...	316	3.56	1 124	0.34
10	11 498	958	5	63	9	...	1 035	3.01	3 116	0.27
8	10 471	873	6	45	9	...	933	2.48	2 309	0.21
6	34 761	2 897	40	308	61	107	3 413	1.91	6 519	0.19
4	645	54	1	6	2	...	63	1.36	86	0.13
	60 654						5 760		13 154	

At the time of the test the system had been entirely completed with the exception of service connections, none of which, however, had been put in. The mains and standpipe had been filled about ten days previously and the hydrants had been thoroughly flushed out, thus removing most of the air. With the standpipe again filled and with pumps stopped, the observation for leakage was made for a twenty-four-hour period by simply noting the rate of lowering of the water level. During this time, the static pressure at hydrants in all parts of the town was found to vary from 37 lb. to 99 lb., and to average for the entire system about 75 lb. A careful inspection of the entire route of the pipes revealed no evidence of large leakage, and it is believed that practically all was at lead joints.

The total loss in twenty-four hours was found to be 22 400 gal., which, corrected for small known drafts and a slight leak in the standpipe, showed a net loss taking place in the underground mains of 20 800 gal. Reducing this to the unit by dividing by 13 154 gives 1.58 gal. per day per linear foot of lead joint, an

equivalent of 9 gal. per capita of the population on the pipe lines. The possible errors in determining ought not to exceed 5 per cent., so that the correct figures for this case should lie between 1.50 and 1.65 gal. per day per linear foot of lead joint. As the construction work was carried out under good average conditions by reputable contractors, employing experienced pipe layers, joint makers and calkers, without the expectation that it was to be tested, it is felt that the results are fairly representative for the size of pipe and class of work.

The following table contains a list of cases, believed to be accurately reported, where similar determinations have been made, and it is presented here for comparison.

This table shows what general experience confirms, that bottle tightness in lead joints of cast-iron water mains is an impossibility. So long as pipe lines are built in this way, and from our present knowledge there seems no better method for general practice, leakage must be reckoned with. The problem, then, is to reduce it to a minimum. In this endeavor two general lines of action are possible: first, the substitution of some more satisfactory material for lead; second, an improvement in the design and construction of the lead joint. Under the first heading there has already been produced a substance called "Leadite" which has been quite extensively used. Whether this will solve the leakage problem and become the universally recommended material for cast-iron pipe joints is still an open question. Under the second heading, a general stiffening of specifications under which pipe is laid, with more careful supervision of joint making, laying in deeper trenches to reduce expansion and contraction, mechanical injury, etc., and rigid tests for leakage after completion would have a tendency to produce tighter work.

The standard of tightness which is to be regarded as acceptable will be subject to much difference of opinion depending upon the point of view. The *seven* gallons per day per linear foot of joint reported by the Metropolitan Water Board as leaking on one section of 20-in. main seems to the writer to be much in excess of a reasonable performance, and no doubt in that case leaks were discovered by the test and afterwards repaired. At this rate a 12-in. main would lose 25 gal. and a 20-in. main 43 gal. per day at

TABLE 2.

System.	Pipe Sizes. Inches.	Pipe Length. Feet.	Pressure. Pounds.	Leakage. (Gallons per Day per Linear Foot Lead Joint.)	Remarks.	Reported by
Providence High Service...	16	29 400	114	0.22	Three years old.	J. R. Freeman, C.E.
Milton, Mass., water-works system	4 to 12	16 900	85	1.30	Ten years old.	J. R. Freeman, C.E.
Nine small water-works systems.....	6 and 8	....	50	0.47	New	J. R. Freeman and C. F. Loweth, C.E.
Metropolitan Water Works, Boston.....	60	8 220	66	0.90	New	Dexter Brackett, C.E.
	48	116 563	50–150	3.16	New	
	42	11 744	50–150	2.43	New	
	36	25 663	50–150	3.19	New	
	30	7 287	50–150	0.81	New	
	24	20 553	50–150	3.44	New	
	20	40 231	50–150	7.00	New	
	16	49 903	50–150	4.65	New	
Plymouth Cordage Co.....	6 to 10	11 780	60	2.00	Fire protection system (old).	J. H. Damon, Chief Engineer.
Hamilton Woolen Co.....	6 and 8	5 500	105	7.30	Fire protection system before repairs.	A. H. Smith.
Hamilton Woolen Co.....	.....	.....	.....	1.30	Same after repairs.	A. H. Smith.
Medway, Mass., Water Works.....	6 to 12	60 654	75	1.58	New	A. H. Smith.

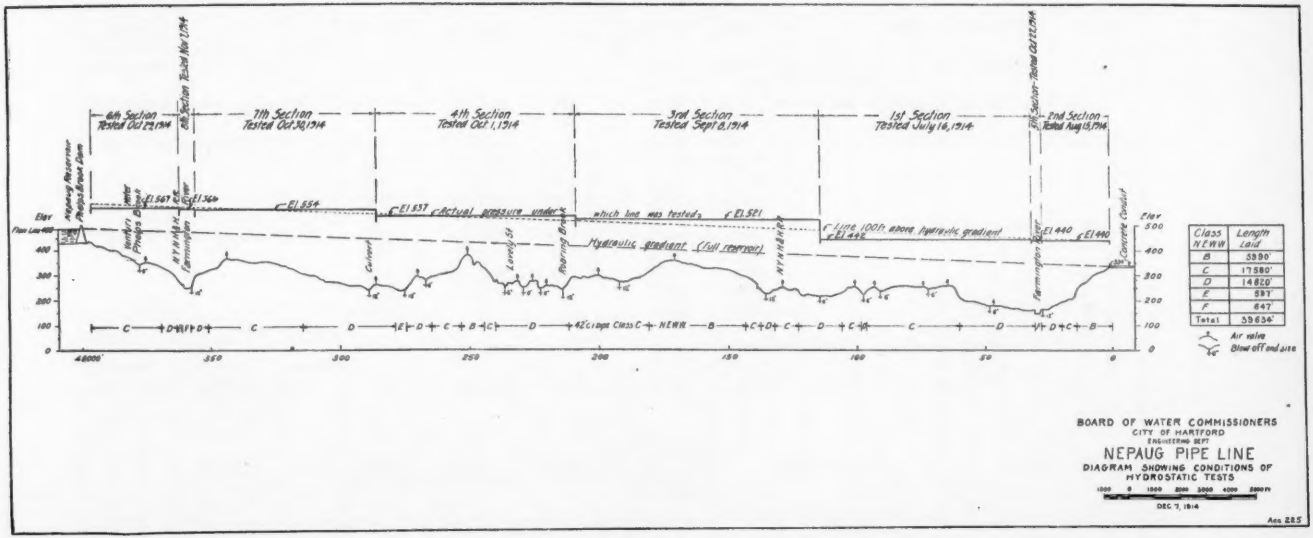

6th Section Tested Oct 22,1914
8th Section Tested Nov 2,1914
7th Section Tested Oct 30,1914
4th Section Tested Oct 1,1914
3rd Section Tested Sept 8,1914
1st Section Tested July 16,1914
9th Section Tested Oct 12,1914
2nd Section Tested Aug 15,1914
Nepaug Reservoir Phelps Brook Dam
Hunter Street Bridge
Farmington River
N.Y.N.H.&H.R.R.
Curtiss
Lovely St
Roaring Brook
Farmington River
Concrete Conduit
El 567
El 564
El 554
El 537 Actual pressure under which line was tested
El 521
Hydraulic gradient (full reservoir)
5' line 100ft above hydraulic gradient
El 442
El 440
El 440
Elev
Flow Line 460
48000'
350
300
250
200
150
100
50
0
C D E D C B C D 42" slope Class C NEWR B C D C D C D C B
Class NEWR
Length Laid
B 5390'
C 17580'
D 14820'
E 591'
F 647'
Total 39634'
Air valve
Blow off and site
BOARD OF WATER COMMISSIONERS
CITY OF HARTFORD
ENGINEERING DEPT
NEPAUG PIPE LINE
DIAGRAM SHOWING CONDITIONS OF HYDROSTATIC TESTS
1000 0 1000 2000 3000 4000 5000 Ft
DEC 7, 1914
Acc 285

FIG. 1.

each joint. On the other extreme shown in the table probably few jobs can equal the record on the Providence High Service of 0.22 gal. per linear foot of joint.

If leakage on new work can be limited to *one* gallon per day per foot of joint under 100-lb. pressure, the performance can be called good and acceptable. It would seem that below this limit, thought and energy might better be expended in tracing other forms of waste than that at lead joints.

DISCUSSION.

MR. C. M. SAVILLE * (*by letter*). The following tables show the conditions and the results of the tests on about 7.5 miles of 42-in. cast-iron supply main for the city of Hartford, laid in 1913–14.

The clause in the specification relating to the testing was:

"*Hydrostatic Test.*

"SECTION 6. 12. The pipe shall be tested in sections of ordered or approved lengths under a static pressure corresponding to a water level everywhere at least 100 ft. above the hydraulic gradient shown on Sheet 2 of the contract drawings. All visible leaks shall be stopped, and the entire leakage from any section under such pressure shall not exceed a rate of 2 gallons in twenty-four hours per linear foot of pipe joint, the length of joint to be figured on the nominal interior diameter of the pipe. Should the leakage exceed this amount, the joints shall be recalked until the leakage under the above pressure is within the limit prescribed. The test pressure shall be maintained for at least twenty minutes. For these tests the contractor shall provide clean water, suitable bulkheads, and all necessary pumps, piping, connections, meters, gages, and other equipment without extra compensation."

MR. GEORGE H. FINNERAN.† I should like to know how many of the water works represented here test main-pipe joints for leakage before back-filling the trench. I know that as a matter of theory such a course ought to be followed, but as a matter of practice I should like to know to what extent such tests are made. In Bos-

* Chief Engineer, Board of Water Commissioners, Hartford, Conn.

† Assistant Superintendent, Water Works, Boston.

SUMMARY OF HYDROSTATIC TESTS OF SECTIONS OF NEPAUG PIPE LINE.

Date Tested.	Data. Section.	Station to Station.	Length.	Number and Size of Joints.	Total Lin. Ft. of Joint, Using Actual Length of Lead Joint as if of Class D Pipe.	Total Lin. Ft. of Joint Based on Nominal Diameters.
1	2	3	4	5	6	7
Aug. 15, 1914	Transition to lower river crossing.	0+79 — 27+85	2 646	223 — 42 in. 2 — 12 in.	2 636	2 459
Oct. 22, 1914	Lower river crossing.	27+38 — 31+21	383	38 — 42 in.	448	418
July 16, 1914	Lower river crossing to Wallace's Swamp.	31+43 — 113+91	8 248	694 — 42 in. 8 — 6 in.	8 193	7 647
Sept. 8, 1914	Wallace's Swamp to Roaring Brook.	114+24 — 208+54	9 430	798 — 42 in. 6 — 12 in. 2 — 6 in.	9 430	8 800
Oct. 1, 1914	Roaring Brook to Culvert near Camp 1.	208+59 — 285+88	7 729	659 — 42 in. 6 — 12 in. 8 — 6 in.	7 800	7 281
Oct. 30, 1914	Culvert near Camp 1 to upper river crossing.	285+98 — 356+12	7 014	592 — 42 in. 2 — 12 in.	6 990	6 518
Nov. 7, 1914	Upper river crossing.	356+18 — 361+93	575	56 — 42 in. 2 — 12 in.	666	622
Oct. 29, 1914	Upper river crossing to end of line at Phelps Brook Dam.	362+05 — 397+15	3 510	301 — 42 in. 2 — 6 in. 2 — 12 in.	3 560	3 320
		Totals	39 535	3 361 — 42 in. 20 — 12 in. 20 — 6 in.	39 723	37 065

SUMMARY OF HYDROSTATIC TESTS OF SECTIONS OF NEPAUG PIPE LINE. — *Continued.*

DATE TESTED.	SECTION.	RESULTS FROM TESTS.				DEDUCTIONS.			
						Rate of Leakage. Gals. per 24 Hours.			
		Test Pressure.	Total Leakage Gallons in 20 Min.		Per Cent. Actual to Allowable.	Total.	Per Lin. Ft. of Pipe Joint on Basis of Col. 6.	Per Lin. Ft. of Pipe Joint on Basis of Col. 7.	Per Inch-Mile of Pipe, Basis of Col. 7.
			Allowable*.	Actual.					
		8	9	10	11	12	13	14	15
Aug. 15, 1914	Transition to lower river crossing.	120 lb. at Sta. 27+25	68.3	33.7	49	2 426	0.920	0.987	115.0
Oct. 22, 1914	Lower river crossing.	120 lb. at Sta. 27+38	11.61	12.50	108	900	2.01	2.15	295.0
July 16, 1914	Lower river crossing to Wallace's Swamp.	120 lb. at Sta. 31+43	212.5	29.9	14	2 153	0.262	0.281	32.8
Sept. 8, 1914	Wallace's Swamp to Roaring Brook.	99 lb. at Sta. 208+54	244.6	83.0	34	5 976	0.633	0.679	79.6
Oct. 1, 1914	Roaring Brook to Culvert near Camp 1.	120 lb. at Sta. 285+88	202.2	197.5	98	14 220	1.82	1.95	231.0
Oct. 30, 1914	Culvert near Camp 1 to upper river crossing.	127 lb. at Sta. 285+98	181.0	0.75	0.4	54	.0077	.0083	0.97
Nov. 7, 1914	Upper river crossing.	135 lb. at Sta. 361+93	17.28	9.13	53	657	0.986	1.06	144.0
Oct. 29, 1914	Upper river crossing to end of line at Phelps Brook Dam.	129 lb. at Sta. 362+05	92.2	16.9	18	1 217	0.342	0.367	43.6
		Totals	1 030	383.38	37.2	27 603	0.695	0.745	87.9

NOTE. — Total length of pipe line from Sta. 6+79 to Sta. 397+15=39 636 ft. The difference between this and the total length tested is due to the untested closure pieces and several untested lengths at Wallace's Swamp and at the lower river crossing.

* Two gallons per linear-foot pipe joint, based on nominal diameter.

ton we do not make them. I am curious to know if there are any cities or towns wherein the practice is carried on religiously, without deviation or exception.

MR. FRANK L. FULLER.* It has always seemed to me very important to test water-pipe systems. On the completion of the Winchendon, Arlington, and Uxbridge systems, this was done by means of a boiler testing pump. This pump has a very small piston or plunger and of course throws very little water, perhaps three gallons per minute. The pump has a lever handle and a stroke about six inches long, and a pressure of two to three hundred pounds per square inch can easily be obtained.

After the pipe system has been filled with water, gates are shut so as to form a closed section of moderate size. The discharge from the pump is connected to a hydrant within this section and the suction to a tight barrel or cask. If the pipe within the section shut off by gates is free from leaks, the pressure can be quickly raised to any desired point. If upon shutting the gates the pressure falls and cannot be raised by working the pump, there is a leak within the section greater than the capacity of the pump. If the reservoir or standpipe pressure does not force the leakage to the surface, so that the leak can be found, some other method must be employed. One method is, with a larger pump to force into the closed section, under sufficient pressure, an amount of water larger than that escaping through the leak. If the trouble comes from a cracked pipe or a poor joint, the increased pressure is likely to still further open the split pipe or the poor joint, and water show upon the surface of the ground.

MR. WALTER E. SPEAR.† The Board of Water Supply has laid no pipe in the main conduit lines smaller than 48 in. For these lines our specifications require the leakage to come within a maximum of two gallons per day per foot of joint. The actual measured leakage ranged from this figure down to less than half this amount.

PRESIDENT METCALF. Do you test them, as a matter of fact, before the pipe is covered?

MR. SPEAR. Hydrostatic tests were generally made on sections

* Civil Engineer, Boston.

† Department Engineer, Board of Water Supply, New York.

between line valves of about half a mile in length, and ordinarily after the pipe was covered. The tightness of the pipe seemed to be largely a question of supervision and the reliability of the workmen. The best results were noted on a job where the contractor had calkers whom he knew and could rely upon. In one organization every joint was marked to identify the workman who calked it, and when any leakage occurred the calker responsible for it was brought to account. We had one line on which a great deal of recalking had to be done because the contractor did not have proper supervision and did not know his calkers.

Mr. S. E. Killam.* As far as the Metropolitan water supply is concerned, the test for leakage on these lines was made as soon as the contract was completed and before the final payment. This is true of all recent contracts with one exception, and that is on a line that was just completed, where it was impossible to test until a parallel line could be put in use.

I was surprised at the figures quoted in the paper just read, on the leakage of a 20-in. main of the Metropolitan Water Works. I think there must have been some leak of considerable size which was repaired before the line was finally put in use.

Last year a test on a 20-in. line 4 965 ft. in length showed a leakage of one gallon per minute, equivalent to .6 gal. per day for each foot of joint. On this line there were twelve joints made of wood staves, which are installed to reduce the amount of electricity traveling on the pipe line. The test was made in a closed trench, and after the line had been under pressure for about seven days. The pressure on this main varied from 35 to 100 lb.

A recent test of the 12-in. submerged line under the Neponset River in the Hyde Park district of Boston showed the line to be practically tight under 150 lb. pressure. The length of this line is 326 ft., of which 134 ft. is of the spherical joint type. This line was laid in 1902. The trench under the river was excavated with a dredge, and the pipe made up on the shore and buoyed across on empty oil barrels, after which the barrel lashings were cut, allowing it to settle into the trench. Under the direction of the State Board of Health, the river channel during the last few years has been deepened and improved for the purpose of draining the great

* Superintendent of Pipe Lines, Metropolitan Water Works, Boston.

area of wet meadows in the central part of the watershed. On August 16, 1915, a leak developed in the river channel, and on investigation it was found that the pipe had pulled apart, presumably by the dredge, which had been at work in this locality. The pipe was pulled into place and the lead recalked and the joint faced with lead wool. A test was then made, with the result given above.

MR. FINNERAN. While we in Boston know of various means and methods of testing sections of pipe lines, and upon occasion have employed them, the question that I should like to have answered is to what degree it is considered desirable to defer back-filling until the pipe joints have proved their tightness. In laying in congested city streets it is desirable to back-fill as quickly as possible, so as to inconvenience the public as little as possible; and it is for that reason more than any other that in Boston we omit the testing before the trench is back-filled. As I said before, we do in many cases test for leakage, but we have no means of knowing which particular joint, if any, is leaking. That can be ascertained in a practical manner only by observation.

MR. MORRIS KNOWLES.* In Pittsburg the practice is to know that the pipes are tight before back-filling.

MR. IRVING S. WOOD.† In Providence the work is all done by the city, and pretty thoroughly inspected. It is not the practice to test the joints before back-filling.

MR. A. E. MARTIN.‡ In Springfield we seldom test the pipes before back-filling.

In the outlying districts it might be possible and practical to test them, but in the main streets of the city where the travel is very congested it would not be practical nor possible.

MR. GEORGE A. STACY.§ As far as practical, we like to test the joints before they are covered. We rely a good deal upon a good man with plenty of time to do the work properly, and rely something on the nature of the soil to detect a leak that would amount to anything. The soil being a hard, compact clay, we cannot lose a great deal of water without its coming to the surface. Our con-

---

* Civil Engineer, Pittsburg, Pa.
† City Engineer's Office, Providence, R. I.
‡ Superintendent of Water Works, Springfield, Mass.
§ Superintendent of Water Works, Marlboro, Mass.

sumption according to the pumping record is such that we think perhaps ignorantly that we have got a very small percentage of leakage. We have not gone into it in a scientific way.

The question comes to my mind that after you have tested your pipe lines, are they going to stay tight under what might be called working conditions; that is,unequal settlement, water hammer, etc.? Are all those joints going to show the same results five or six years afterward as they do at the time they are tested?

I have a 16-in. force main two miles long that is under a pressure of from 60 to 182 lb., and it never showed any leaks until seven or eight years after it was laid. Since then we have had five or six leaks, these extended over ten or twelve years, all would be called small leaks, and were easily stopped. We had one recently down near the pumping station, where our greatest pressure is; the pipe had been in there twenty years and never caused trouble. The lead had started out and it was some work to drive it back as we did not shut the water off. We have had no trouble with it since. In laying this line we crossed a brook, where, unfortunately, the clay jointer gave way, and they had to pour the joint two or three times. We expected trouble here and we have watched that joint twenty years but have never found any. I think that joint is as good as any in the line. I think it is a proper thing, and I guess we all agree on that, when it is practical, to test all our joints before they are covered. I have just laid a short line, or am laying it, with Leadite. We left three or four joints to see how they looked when we turned the water on, but all we ever found was a little froth, and the next morning that was gone, and the joints tight, and they seemed to grow tighter as they grew older; why, I don't know. If the Leadite is as durable as the pipe, I do not know why these joints should not remain tight during the life of the pipe. I have one or two joints that I made with Leadite about five years ago. We have kept an eye on them, especially one joint where the Leadite was at the wrong temperature. That joint leaked a drop or two. We dug down to that before the season closed and found it absolutely tight. The only leak that did not stop that I have had in using Leadite is where we had a little water in the joint. I found there that I did not know how to make Leadite tight on a wet joint. I suppose that might be overcome, but I think if I

had one that was pretty wet I should use lead or lead wool in making the joint.

A MEMBER. There is one point I have not heard any one mention. Some years ago I was laying a line of pipe up to a spring which was to supply a small town. There were no streets to be crossed, so we left the trench open to test the joints, and the pipe was exposed for quite a while. The water ran in; a few joints sweated and we calked them. The contractor had his men all busy at another part of the line by that time and he did not want to bring them down to back-fill, so we let the pipe lie open. It was in the fall with cool nights and hot weather in the daytime, and we found that every day the pipes expanded and every night they contracted, and in the morning we would find sweaty joints.

MR. GEORGE F. MERRILL.* It brings to my mind an experience we have had at Greenfield. We have a line between our reservoirs, that is left uncovered, subject to the temperature changes. I find those joints after they are calked quite often get to leaking — I suppose because of the temperature, the expansion and contraction. I presume that would work more or less on a line where the trench was left open for a long time.

MR. FRANK L. FULLER. While it is perfectly feasible to test an extension to an old system before back-filling is done on a line of pipe, I think it is true that in the majority of the country systems the pipe is often laid before there is any possibility of testing it. That is, the pipe laying may be the first thing that is done, and the installing of the pump and the completion of the reservoir is the very last part of the work, so there is no opportunity to test the pipe line until after it is back-filled.

MR. W. C. HAWLEY.† There is one fact which I think we should keep in mind in considering this question of leakage. It has been customary to compute leakage on a rate per linear inch of joint or per inch-mile of pipe. Is this the proper basis for comparison? As a matter of fact, the great bulk of leakage is not caused by a general leakage from every or even many joints. My experience, and I have seen many miles of pipe uncovered for the purpose of replacement with larger pipe or for tapping, has convinced me that a very

* Superintendent of Water Works, Greenfield, Mass.
† Superintendent of Water Works, Wilkinsburg, Pa.

large percentage of joints are absolutely tight. Most of the leakage is caused by a few large leaks; some is from stuffing boxes on gate valves, which obviously has no relation to diameter of pipe or length of joint. The frequent use of the pitometer on many water-works systems seems to confirm my contention. This instrument does not locate general leakage, but does find the large leaks. I mention this so that those who have not given the matter consideration will not conclude from our discussion that a general leakage is to be expected. I think that we should also consider carefully whether or not the basis which has been chosen for stating the amount of leakage is a desirable one or if a better one should be chosen.

We test every joint before it is back-filled, and if we cannot lay but half a dozen joints we put in a plug and run it with Leadite and test, cut out the plug in ten or fifteen minutes and go ahead.

In Atlantic City we used lead, and generally tested our pipes before back-filling.

MR. EDWARD D. ELDREDGE.* I do not put as much confidence in testing the pipe as in insuring a good foundation under the pipes. I think some large leaks occur where the pipe settles unduly, although under test, before filling, no leak may appear. In back-filling the trench the first process should be to ram the filling firmly under the pipe, to be sure that whatever results from the weight of back-filling, the pipe is going to maintain its position. Then if the calking is done in a first-class manner the probabilities are that the joints will be tight. In our system of about 15 miles of pipe, we do not know of any leakage. The town is principally a summer resort. The winter population is only five or six hundred. There have been days in the winter when the consumption was only 10-000 gal. That would indicate a very small leakage. We make sure that in back-filling no settlement of the pipe occurs. Sandy soil favors this operation.

MR. A. E. MARTIN. In following up what Mr. Hawley said, about the leakage not being from every joint, we had a little experience in that line during this last summer or early in the spring. On account of changes in grades of streets we had to re-lay and lower about a mile of 30-in. main, and in the whole length of that

* Superintendent of Water Works, Onset, Mass.

main we did not find half a dozen joints that were even sweating. The line was laid about 1892. I think it is safe to say that Mr. Hawley is right in that the leakage is not from every joint but generally from some few bad ones.

MR. SMITH. I am very glad this feature of the discussion has come up, because I think very likely my paper has given a false impression on that point. I know that what the gentlemen say is perfectly true, — it is not every lead joint that leaks. My own experience and that of many others with whom I have talked confirms this. The water commissioner of Worcester, Mass., once said to me, " We do not have any leaks in lead joints. We have a bottle-tight system. I have seen miles and miles of pipes with lead joints uncovered without a single leak," testimony which proves that at least some joints do not leak. There are however, many small leaks besides those large ones which Mr. Hawley has called attention to, and this paper was intended to emphasize this fact and to arrive at some more definite idea of the volume of leakage which must certainly be expected on every large cast-iron pipe system. Therefore it seems to me that the experience of these water-works men, if it can be formulated and got into shape, would establish just such a standard as I have been trying to set before you. The records are pretty meager and your accumulated experience would have great value in establishing a basis of judgment.

MR. WILLIAM F. SULLIVAN.* This discussion has brought out a lot of information regarding leaks on lead and Leadite joints. My own experience has been such that whenever the pressure was put on uncovered pipes, we have inspected the joints to see what leaks there were, if any. Occasionally we would find small leaks. Recalking or " touching up " the joints would stop any " weeping." On any pipe line that had been back-filled and that we had doubts about being tight, we would close the gates and by-pass one gate, setting a small meter on the by-pass and find out the extent of the leak. We periodically test a river crossing which we know leaks. It is a 24-in. pipe, 250 ft. long. At present the extent of leakage on this section of pipe is 164 gal. per day.

MR. GEORGE F. MERRILL. There is one point that has not

* Superintendent of Water Works, Nashua, N. H.

been brought out. Mr. Smith's paper is of great value and shows us what a new pipe line should be. There are, however, two elements of leakage, — one, underground leakage, and another, under-registration of meters. Where we have an old system the element from the under-registration of meters might mean quite a considerable amount.

[*Note.* Additional recent discussion of this subject will be found in JOURNAL N. E. W. W., XXVIII, 315 (1914), — "Allowable Leakage from Water Mains," by E. G. Bradbury.]

DECOLORIZATION OF WATER BY STORAGE.

BY RALPH H. STEARNS.

[*Read September 8, 1915.*]

It has been generally recognized that when the colored river waters of New England were stored in reservoirs for a considerable time a substantial reduction in color was effected. In connection with the improvement of the quality of the Sudbury River water, this subject was carefully studied under Mr. Desmond FitzGerald, chief engineer of the Boston Water Board, in the years 1891–1894, and the amount of the reduction in color by storage for certain of the Sudbury reservoirs was estimated. The subject "Decolorization of Water" was fully treated at an informal discussion before the American Society of Civil Engineers in 1901.*

The experience on the Sudbury watershed largely influenced the development of the Wachusett watershed, and resulted in the construction of a reservoir of extraordinary size and with a clean bed to eliminate the tastes and reduce the color of the water. Now that the records of the colors of the Wachusett reservoir water are available for a number of years, a further study of the reduction in color and its relation to storage has been made, and the results are herewith presented.

It must first be understood that the results apply to New England river waters, colored with a vegetable stain which originates largely in swamps, from the peat and decaying vegetable matter. There is generally only a very slight turbidity in the water, the sedimentation of which would have but a small effect on the color.

Iron plays a peculiar part as a coloring agent in reservoir water. A study of the relation of iron to color, made in Boston about 1892, revealed the following facts:

Where there is plenty of dissolved oxygen in the water, the iron is kept in its insoluble ferric state and is therefore precipitated

*Trans. Am. Soc. C. E., Vol. XLVI, p. 141.

and remains on the floor of the reservoir. When the oxygen in the water becomes exhausted, this ferric iron may be reduced to its ferrous state by the surrender of its oxygen to the organic matter, and may then be taken up by the water. A lack of oxygen often obtains during the warmer months at the bottom of deep reservoirs, below the plane reached by the circulation of the upper waters, where organic matter is abundantly supplied either by the bottom or the influent water. The colorless ferrous iron upon oxidation imparts a high color to the water, which is gradually reduced to normal again by precipitation of the iron. Iron has appeared on occasions in the Hopkinton and Borden Brook reservoirs, and frequently in Milham Brook, but not in the other reservoirs listed in the table.

In earlier discussions it has frequently been stated that the bleaching of water was due entirely to the agency of sunlight. That sunlight is a bleaching agent was conclusively proved by exposing colored waters in bottles to the sunlight, while similar samples were kept in the dark. The former were in time completely decolorized, while the latter were practically unchanged. Also, by placing bottled water at different depths in a reservoir, the effective bleaching was found to be confined to the upper few feet, while at a depth of 10 ft., in a reservoir water having a color of 40, no appreciable reduction was found after a month's exposure.

The conclusion that bleaching is the result of sunlight alone is, however, not borne out by the actual observations in deep reservoirs. In such reservoirs a complete mixing occurs in the early spring, after which the surface water becomes warmer and of less specific gravity than the lower waters, and vertical circulation between the upper and lower strata ceases entirely until the fall overturn occurs. In this bottom water, thus left stagnant and beyond the reach of sunlight, decolorization goes on, and at a considerable rate.

Taking, for example, the Wachusett records for 1907–1914, the maximum color reached at the dam after the spring overturn averaged 18.6, and this was reduced before the fall overturn to 14.4 at the bottom, as against 12.6 at the surface. In other words, the rate of reduction was about 30 per cent. less at the bottom.

At the Hopkinton and Ashland reservoirs, with their highly colored waters, the decolorization at the bottom appears to have been about one half of that at the surface. It may be urged that the reduction of color at the bottom is due to dilution by ground water, but this is of no such quantity near the dams as to dilute the water of these reservoirs even when drawing them down.

The only other explanation of decolorization at the bottom is slow oxidation without sunlight. As the dissolved oxygen in the water at the bottom of a stripped reservoir supplied with good water does not become exhausted, this seems the rational explanation. The failure of bottled water to bleach was probably due to lack of oxygen and insufficient time.

The decolorization of water by storage, then, is apparently pure bleaching, brought about by sunlight and by oxidation, and taking place at the bottom of deep reservoirs in cases where there is plenty of dissolved oxygen in the water as well as at the surface. The bleaching action, while always going on, is greatly accelerated during the summer months, and becomes a minimum when the reservoir is covered with ice.

It appears that the reduction in color is proportional to the initial color — that is, the percentage reduction is independent of the initial color. Also, it has been shown that decolorization will continue to completion, both in bottles and in large natural lakes.

The reservoirs which were studied, as seen in the table below, were mainly those of the Metropolitan Water Supply, but a few others were added where reliable records of influent and reservoir colors were available. The results are based on averages of from five to fifteen years, which tends to neutralize any anomaly of a single month or year.

During the years 1906 and 1907, the Wachusett reservoir was filling for the first time, and the storage capacity was therefore taken as equal to the maximum quantity of water held in storage during each of these years. In the year 1907, there was an abnormally high run-off during the last three months, which was reflected in the high color of the water during the first two months of 1908, and in order to give a truer comparison those three months were included with the year 1908.

Decolorization of Water by Storage.

Name of Reservoir and Supply.	Years Used in Average.	No. of Years Used.	Area of Watershed. Sq. M.	Storage Capacity. Total.	Storage Capacity. Per Sq. M.	*Yield per Sq. Mile. Mil. Gal.	Length of Storage. Days.	Average Depth of Res'r. Ft.	Color of Influent Water.	Color of Water at Dam.	Per Cent. Color Remaining.	Per Cent. Color Reduction.
			Stripped Reservoirs.									
1. Wachusett	1908–1914	7¼	118	65 000	550	0.894	615	48	43.5	14.7	34	66
2. Wachusett	1907	¾	118	38 600	327	0.920	355	39	45	23	51	49
3. Wachusett	1906	1	118	34 500	292	1.043	280	38	46	24	52	48
4. Hopkinton, Sudbury	1895–1897, 1899–1903	8	5.86	1 520	260	1.111	234	25	113	60	53	47
5. Ashland, Sudbury	1891–1897, 1899–1903	12	6.43	1 416	220	1.066	206	26	100	65	65	35
6. Reservoir No. 3, Sudbury	1891–1896	6	27	1 180	45	1.012	45	15	84	69	82	18
7. Reservoir No. 2, Sudbury	1900–1903, 1905–1914	14	47	530	11.3	0.863	13	12	76	69	91	9
8. Fall Brook, Leominster	1898–1903, 1905–1913	15	1.26	386	306	1.075	285	14	36	15.5	43	57
9. Hobbs' Brook, Cambridge	1900–1903, 1905–1914	14	7.25	2 097	289	0.863	335	14	59	18	30.5	69.5
			Unstripped Reservoirs.									
10. Borden Brook, Springfield	1910–1914	5	8	2 500	312	0.925	338	36	75	57	76	24
11. †Milham Brook, Marlborough	1901–1903, 1905–1913	12	3.56	315	88	0.853	103	15	47	45	96	4

* Based on Wachusett or Sudbury records for the years given.

† Stripped to 10 ft. below flow line, but oxygen becomes exhausted in deep portion.

In determining the colors of the inflowing water, the average color of the inlet was weighted in accordance with the quantity of water flowing each month, this being based on the run-off records of the Wachusett or Sudbury watershed, as appeared most comparable. In the single case of Reservoir No. 2, the direct average of the influent colors was used, as the reservoir contained but thirteen days' average run-off. The reservoir colors are direct averages of the published monthly records. All colors were given in or converted to the platinum standard.

Reduction of color is not only a function of the storage per square mile, which is the base used in the accompanying diagram, but also of the run-off per square mile. In this connection it must be noted that the records available for the Wachusett reservoir cover a period of abnormally dry years, and a slightly smaller reduction must be expected when the yield is high. The records for the Sudbury reservoirs, on the other hand, are for years when the yield was above the normal. The number of days that the average yield is held in storage would be the more logical base, but the one used shows the results closely enough and is definite.

To obtain an accurate measure of the bleaching accomplished, the bulk of the inflow must be brought into the reservoir by a single surface stream, or by several streams, the relative discharges of which are known. Such conditions were substantially realized in the cases of the reservoirs studied. In general, the rainfall and evaporation will about balance, so that but little dilution takes place from rainfall.

Results.

The results appear in the accompanying table and diagram. The diagram shows as abscissæ the storage capacity of the reservoir per square mile of watershed, and as ordinates the per cent. reduction in color of the inflowing river water resulting from its passage through the reservoir.

It will be seen that the curves determined by the points plotted show a progressive reduction in color as the storage per square mile increases. This reduction in the case of the Wachusett

amounts to 66 per cent. The line for unstripped reservoirs is added only to indicate the general position on the diagram, as the data are too limited and too variable in this case to justify any analysis.

DIAGRAM SHOWING REDUCTION OF COLOR BY STORAGE

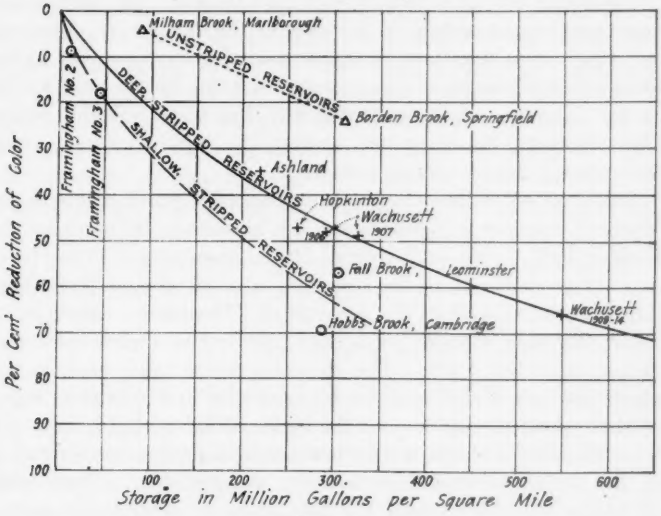


FIG. 1.

The maximum color in a reservoir is normally attained in May or June, following a period of heavy inflow, after which the bleaching takes place actively and the color decreases until another flood period occurs.

The maximum color of the influent of the Wachusett for any month was 70, while the maximum of the reservoir near the dam for any month was 29. This color resulted from the 1907 floods, before the reservoir had filled for the first time. In 1911, as a result of very small inflow, the bleaching action went on until the color was reduced to 7, which color obtained from the surface to the bottom of the reservoir. This color was maintained for a period of three months, while the color of the influent for these same months, which was of considerable quantity, averaged 45.

The color of the influents of the Ashland and Hopkinton reservoirs on a few occasions exceeded 200 during the months of small run-off of the years above noted, while the maximum recorded color of the reservoir water near the dam was 107 for the Ashland and 96 for the Hopkinton reservoir.

The colors for the month of each year in which the color was a maximum were averaged in the case of the Wachusett, Ashland, and Hopkinton reservoirs, and the reduction in color was found to be about five sixths of the average reduction for the year shown in the diagram, when compared with the same influent colors. This indicates the insurance against the highly colored water reaching the distribution system.

Evidence, other than the bottle experiments, which points to the effect of sunlight in accelerating the bleaching, is found in the shallow Fall Brook and Hobbs' Brook reservoirs. These have an average depth of 14 ft., and show a much greater percentage reduction in color than the Ashland and Hopkinton reservoirs of about the same storage per square mile but of higher color and almost twice the depth. The bleaching which takes place in the upper few feet of the reservoir is apparently many times as rapid as that which occurs beyond the range of the sunlight, but, due to intermixing with the waters just below, complete decolorization at the surface of reservoirs is never accomplished. These considerations would indicate the advantage of shallow reservoirs, in this respect.

The results at Borden Brook and Milham Brook reservoirs show the effect of leaving the soil, etc., on all or a large part of the reservoir bed. For a period of years color is absorbed from the reservoir bed, and this in a measure offsets the normal decolorization due to storage. There are instances where for this reason the reservoir color exceeds that of the influent streams.

In order that advantage can be taken of the bleaching effect, it is, of course, necessary that the supply be taken from the lower end of the reservoir and that the greater part of the inflow shall be at the more distant points. In such a case, a somewhat imperfect piston action takes place, and the raw river water travels but slowly toward the outlet. To obtain the best results the reservoir capacity should exceed the maximum run-off of the

winter and spring months, in which case most of the influent would be subjected to a summer's bleaching before using.

Where a large portion of the inflow comes in near the lower end of the reservoir, a more general mixture of the water occurs. Even if it all comes in at the upper end, it is conceivable that an abnormally cold or warm inflow, having a greater or less specific gravity than the reservoir water, might run along the surface of, or beneath, the reservoir water and later become generally mixed with it. In the last two cases the reduction would be the result of dilution and would yield a less desirable effluent. There is evidence of a slow circulation in all reservoirs, due to winds and temperature changes, together with the piston action.

It is now recognized that the reduction of the color to an inappreciable amount is one of the requisites of a satisfactory supply, and, due to its great storage, the Wachusett reservoir seems to have performed this function acceptably.

DISCUSSION.

MR. ALEXANDER POTTER.* Would Mr. Stearns give us a more extended definition of the three terms, — an unstripped reservoir, a deep stripped and a shallow stripped reservoir? I think that has some bearing upon the interpretation of the results.

MR. STEARNS. A stripped reservoir is one in which the soil containing organic matter has been taken off the bottom.

There should properly have been a comma between the two adjectives on the diagram; a deep reservoir and a stripped reservoir was meant.

MR. POTTER. A distinction can very properly be made between "deep stripping" and "shallow stripping." Practice in reservoir stripping has been modified considerably within the last ten years. Then it was considered proper to remove all roots to a depth of 2 ft. to remove all soil containing organic matter, and to take other precautions involving great expense to secure a clean bottom. This method can properly be called "deep stripping." At the present time, it is considered proper to allow roots and stumps cut down to the surface to remain in place over the major portion of

* Civil Engineer, New York, N. Y.

the reservoir, covering such stumps with gravel and clearing off the brush, grass, and vegetable matter by burning. This method can properly be called "shallow stripping." It is not an unstripped reservoir.

The writer was in hopes that Mr. Stearns's studies on "decolorization" would adduce some proof that the more recent practice of less thorough and less expensive reservoir bottom clearing was justified. The paper, however, seemingly confines itself to conditions under the two broad classifications, stripped reservoirs and unstripped reservoirs.

Mr. Stearns. The operation of removing the trees, stumps, and vegetation is, I think, more generally spoken of as "clearing," and the reservoirs referred to in the paper as "unstripped" were "cleared" in such manner. The comparison Mr. Potter desires is therefore shown on the diagram as far as it goes.

Mr. Edward D. Eldredge.* I would like to ask the speaker if he can inform us a little more fully on the spring and fall overturn, — the cause and the process.

Mr. Stearns. In the summer the surface water is very much warmer and very much lighter in specific gravity than the lower water. As the surface water cools in the fall, it becomes heavier, and when it gets cooler than the bottom water it begins to sink down and the whole reservoir mixes up together. It takes an uniform temperature, an uniform color; uniform in all its characteristics. The same thing occurs again in the spring when the surface water warms up from the freezing point to the temperature of maximum density.

Mr. Allen Hazen.† There is one practical difficulty in carrying out an investigation like that which Mr. Stearns has described, which has always seemed very formidable to me, and I would like to know just how Mr. Stearns managed it, — that is, to find out just what the color of the incoming water really is. Mr. Stearns gives some statistics for the Borden Brook Reservoir. Now, I am not aware of any record that shows adequately the color of the incoming water. It is true that certain examinations are made, but the flows fluctuate, and the flood flows are very slightly

* Superintendent of Water Works, Onset, Mass.
† Consulting Engineer, New York.

represented in the monthly samplings, and the low water flows are given an undue representation. Then there are many tributaries and only some of them are sampled. Certainly the samples do not represent all of the water, and I, for one, should admit right off that I do not know of any way by which the color of the incoming water can be determined.

In a broader aspect of the case, the result of my study and observation has led to the conclusion that while some improvement takes place in many waters by storing them in open reservoirs, it is never possible to get a water in that way that is acceptable, that is to say, that is up to the standard that cities in this century and this country reasonably demand. The water may be improved, but it is still a dirty, inadequately cleaned water. The only way that these reservoir waters can be made into good water is to filter them; and when the filtering is done the preliminary improvement that comes through these processes which Mr. Stearns has described is ordinarily of very little practical importance.

MR. STEARNS. In answer to Mr. Hazen's question as to how those colors of the influent water were derived, the analyses are made by the State Board of Health in Massachusetts, and each color is multiplied by the amount flowing in during the period which that color represents. If they were monthly it would be weighted according to the flow of water during each month. Thus we obtain the entire mass of color which enters a reservoir during any year, and, by dividing this by the entire amount of incoming water, the average color of the whole influent mass is found. This color is compared with the direct average of the colors in the reservoir near the dam.

In regard to the improvement in the water, the paper showed that the color of the Wachusett reservoir for the past seven years has averaged 14.7, if I recall the figure, which is generally considered a clean water and, as far as the aspect of color is concerned, I think an acceptable water.

MR. W. C. TANNATT, JR.* I noticed on that diagram that the curve of reduction in the unstripped reservoir was practically parallel with the curve of reduction in the stripped reservoir, with

*East Hampton, Mass.

the exception of that point where the capacity was three hundred million to a square mile, watershed. Now, might it not be that if the reservoir was continued, say, to eight or nine hundred million per square mile, the advantage of stripping would disappear because the proportion of advantage is decreasing? Might it not be a fact that there comes a time when the stripping would become uneconomical?

MR. STEARNS. It is a question whether the stripping might be uneconomical or the increase in the size of the reservoir might be. That is, it does not pay to develop the reservoir any further than the Wachusett was developed, evidently, because the line does tend to become parallel with the base line.

PRESIDENT METCALF. Is it assumed, Mr. Stearns, that you take your measurement of the water at the time of the flood flows at frequent intervals? That is, do you take your measurement of color at the beginning of that period only, and assume that that color continues through the period of flow, or do you take colors at frequent intervals during the passage of the flood wave? Wouldn't there be a high color in the first flush of water, which comes from the swamps into the reservoir, and wouldn't the color decrease as the wave recedes? What assumption is made as to the method of determining your color record?

MR. STEARNS. These colors are usually taken monthly, at certain dates, irrespective of any floods, and it is only by getting an average over a large number of years that you can really count on the results. That is what was actually done, for in most cases there were ten years or more in the average, which would neutralize any anomaly in any one observation of one flood.

PRESIDENT METCALF. The analogy to what I suggested would be found, of course, in the first discharge of the sewers in times of storm. There is a great difference in the quality of the effluent that you get from the first flush and the last few hours of the storm. I wondered if that same sort of result was obtained in the flow into the reservoirs. I judge from what you say that it is, but that you hold that it is neutralized by the average. Is that not true?

MR. STEARNS. Yes.

MR. DANIEL D. JACKSON. I was connected with the old Boston

water supply as their chemist, and at that time Mr. Fitzgerald carried on a great many experiments on the decolorization of water by storage, but it was impossible to determine how much color was removed by storage and how much was due to dilution. It would seem from the diagram that the reservoirs having the largest watersheds were the ones which got the greatest decolorization. While we know that there is a decolorization due to the sunlight, that action cannot go very deep beneath the surface. The action must be pretty closely confined to the first few feet of water. It has always seemed to me that the decolorization in large reservoirs was to a large extent due to rainfall and to the flow of water coming in from underground from perhaps other directions as well as from the stream itself, and also to the fact that owing to sudden variations we are unable to gage at all accurately the actual color going in. The final portion of a stream would give you practically a decolorized water. So I should say from the observations taken years ago that the greatest decolorization was due to dilution by rainfall and subsurface flow, though there is undoubtedly a decolorization due to sunlight. Just what percentage that is it is impossible to tell.

MR. STEARNS. Do I understand that that dilution is due to the rainfall that falls directly on the reservoir?

MR. JACKSON. No, on the watershed.

MR. STEARNS. The rain that falls on the watershed is what brings all the color into the reservoir. Otherwise it would be decolorized as the large natural lakes are, like Lake Winnepesaukee and others.

MR. JACKSON. The greatest part of the color which comes into a reservoir is due to the sudden flushing of some swamp area bordering on or at the headwaters of a stream. At the beginning of the flood flow the color is suddenly very high and is then gradually reduced until the dry weather flow is reached, which is fairly low in color. Unless samples and gagings were taken several times a day throughout the entire period of observation, no accurate measure of the color entering the reservoir can be observed. In most reservoirs there is also a constant dry-weather flow, entering the reservoir from below the surface, which is practically colorless, having passed through sand which has removed the color.

In other words, it is a very difficult matter to gage how much decolorization has actually been brought about by storage in the sunlight.

The stripping of small reservoirs for the purpose of removing organic matter is undoubtedly practical, but large reservoirs can be as a rule handled more economically by filling and flushing several times as we did in the case of the New Croton Lake. After the third flushing, the organic matter had been removed and the greater part of the submerged area was found to be clean sand or clay.

MR. R. S. WESTON* (*by letter*). There is a force other than bleaching and oxidation which explains why certain waters decolorize, namely, coagulation.

Much of the coloring matter in water is in colloidal suspension, the particles being so fine that they are not influenced by gravity. They are prevented from coalescing or agglomerating by electrical or mechanical forces, which need not be described. When these forces are overcome by agitation, contact, light, loss of gases, etc., the fine particles gather into groups which are large enough to precipitate. The highly colored Dismal Swamp water (color 500 to 1 000 or more) used to be esteemed highly for the supply of seagoing vessels. After storage in the waterbutts, on board ship, in the dark and constantly agitated, it "works," as the old sea captains say, and becomes remarkably clear and palatable. This "working" process is the sudden precipitation of the colloidal color. The color is not oxidized when precipitated, but may become so later.

The precipitated colloidal matter or ooze must collect on a reservoir bottom, and therefore the character of the water in a stripped reservoir at least must be influenced to a great degree by it, and if the rate of accumulation be greater than the rate of oxidation or consumption by organisms, the ooze, not the bottom, will ultimately determine the character of the water even in an unstripped reservoir. It seems reasonable that the storage of clear waters in dirty reservoirs would impair the quality of a water permanently, and no amount of stripping would prevent the growth of organisms in a water containing abundant food material.

* Consulting Sanitary Engineer, Boston, Mass.

It is to be regretted that there are so few data for unstripped reservoirs. While it is true that the stripped reservoirs of Massachusetts supply waters of the best appearance obtainable by impounding, it is also true that the educated public prefers a water having a color of less than 10 p.p.m. and no disagreeable odor or taste at any time. In most cases this result cannot be obtained profitably by storage alone, and, if other methods of purification are required, it is doubtful if the expense of stripping is warranted.

Mr. Stearns's paper is timely and interesting. It adds to our scanty data on this important problem, all of the factors of which, in the writer's opinion, are not yet known, or if known are not recognized.

MR. E. E. LOCHRIDGE* (*by letter*). The whole question of the decolorization of water by storage is one of a great deal of interest with all water-works men, and especia ly when new storage is contemplated, as a desirable appearing water is being demanded more and more. Iron undoubtedly plays a part as a coloring agent in a reservoir water, but its state is much more complicated than that of a ferrous or a ferric salt. Not only do iron compounds add to the color of the water, but iron salts undoubtedly act as coagulants with consequent color reduction under some conditions. It seems entirely probable that the iron content of a reservoir is in the form of some organic compound and not in a ferrous or ferric salt to any appreciable extent. Only a portion of the iron in many reservoir waters will be removed by oxidation, coagulation, filtration, or by a thorough aëration, or by a combination of these factors. It is entirely probable that a scientific study of the soluble iron compounds of surface water will reveal much, both as to the nature of water, but also the rate and method of decolorization of such waters.

It does not seem to me that the illustrations given by Mr. Stearns, of stripped and unstripped reservoirs, are sufficiently comparable for drawing conclusions as to the decolorization in the two types of reservoirs. Reservoirs for comparison should be of given capacity, about the same length of storage, and they should also be comparable as to depth, location, and quality of water received into them. The elevation above sea level and their usual seasonable temperature ranges, as well as the amount

* Chief Engineer, Springfield Water Department.

which they are depleted during the season, has also a great deal to do with the amount of decolorization. A question of growths in the water and consequent change of organic content must also be a considerable factor. The Borden Brook reservoir, listed as No. 10 in the table, was stripped to a depth of 15 ft., and especial attention paid to the cleaning of the remaining section.

Believing that as good a representative of an unstripped reservoir as could be obtained would be the Ludlow reservoir, which has been notorious for its objectionable growths and tastes for a great many years, I have made a careful study of the flows, depletions, and colors of this reservoir over a number of years. By its peculiar method of use by which the water was by-passed to the city at certain times, I find it is impossible to get records in a number of years. During 1906, however, the city began the filtration of this water, and its use became normal during the last three years of its use by Springfield. The figures for 1906, 1907, and 1908 are given.

Year.	Average Influent Color.	Color at Outlet.	Per Cent. Removal.
1906	49	28	43.0
1907	46	27	41.5
1908	47	27	42.5

The storage capacity of the Ludlow reservoir is 1 855 million gallons, or a per square mile development of 92.5 million gallons, average depth 8 ft. The bottom is thoroughly mucky. As the outlet colors are comparable in other years with the outgoing colors of these years, it is entirely probable that the percentage reductions are substantial to same as in other years. The inlet colors are used in conjunction with the proportional flow for that month. This reservoir was put in service in 1875 and the watershed tributary was doubled fifteen years later. The per cent. color removal in these years of 42.3 would compare favorably with the average of 44.3 in the nine stripped reservoirs listed. Analyses at the filters during these years indicated an iron content in the reservoir which at times exceeded one part per million, while the filter effluent contained at least one half of this amount even after double aëration. Dissolved oxygen was always present, and in the effluent frequently approached saturation.

THE WATER SUPPLY OF SALEM AND BEVERLY.

BY FRANCIS F. LONGLEY, C.E., NEW YORK.

[*Read September 7, 1915.*]

The cities of Salem and Beverly have for many years past taken their water supply from Wenham Lake, which lies in the towns of Beverly and Wenham. This use dates back to the year 1864, when the legislature granted to the city of Salem the right to use the water of Wenham Pond, with a provision that the pipes supplying Salem should be carried by some convenient route through the town of Beverly, and that Beverly should be entitled to the reasonable use of the water upon paying an equitable compensation therefor. The first actual use of the water in Salem was in 1868, and in 1869 Beverly began making use of the water through the setting of certain hydrants.

For a number of years both cities thus drew water from the same mains. The provision for Beverly's compensation to Salem for the water used was not definite enough to be satisfactory to the town people of Beverly, and after some years of effort to adjust this satisfactorily, during which time there were some complaints of insufficient supply and lack of pressure, the selectmen of Beverly were authorized to petition the legislature for authority to take a separate supply from Wenham Lake for the town of Beverly.

As a final result of this action of the town of Beverly, an act of the legislature was passed in 1885 granting the town the necessary authority to build independent works, and construction work was commenced in 1886. In September, 1887, the town of Beverly stopped drawing water from the Salem pipes and commenced the use of this new system.

From that time to the present, the two cities have drawn their supplies independently from Wenham Lake, with independent mains, service reservoirs, and pumping stations.

The draft of water by two cities from one rather limited source

suggests the desirability of joint action in matters pertaining to these supplies. They have, in general, been administered separately since 1887, but as the consumption of the two cities has increased and approached the limiting capacity of the source, the cities have acted in conjunction in securing certain additions to this capacity.

The drainage area of Wenham Lake is about 2 250 acres, including about 250 acres of water surface. The storage in the lake, to a depth of 14 ft., which is about the limit of draft with present equipment, is about 900 million gallons, and this could be increased to about 1 200 million gallons by drawing the lake down 20 ft.

In the early nineties the probability of a shortage of water was so great that the cities were forced into action. In 1895 a dam was built on Miles River forming what is called the Longham Pond. The crest of the dam is at an elevation 5 ft. above the high-water line in Wenham Lake, and a 36-in. cast-iron pipe line conveys the water by gravity from this auxiliary collecting basin into Wenham Lake. After this was done, the total area draining into Wenham Lake was about 4 350 acres, including about 305 acres of water surface. Some years thereafter there was a period of deficient rainfall, during which the water in Wenham Lake dropped to a dangerously low level, and the cities, therefore, made provision to pump water into Wenham Lake at time of heavy flow from a brook flowing from Norwood's Pond, supplementing the supply by the partial flow from about 1.3 sq. miles. It is estimated that the yield in the average year is now about 6.5 million gallons and in a dry year only about 4.7 million gallons a day.

In the year 1914, the average daily draft from Wenham Lake was over six million gallons. It can readily be seen, therefore, that the present situation is a menace to both cities. For some years past they have clearly foreseen the necessity of procuring an increased water supply, and the following steps were taken with this end in view.

In 1910 a report on this subject was rendered to the cities of Salem and Beverly by Mr. William S. Johnson. In 1911 the State Board of Health was directed to investigate the matter of

water supplies for these and other cities and towns, and a report was rendered in 1912. In the same year other reports were made by Mr. Johnson and Mr. George A. Kimball.

In this year of 1912, the prospect of a shortage of water had become so threatening that the appointment of a special commission was authorized by the legislature to consider the entire question in a comprehensive way, the purpose being apparently to fix a basis for the policy of the entire district in regard to water supply for the future. A report was rendered by this commission early in 1913, accompanied by reports from Allen Hazen, consulting engineer, and Guy C. Emerson, engineer to the commission. The substance of their conclusions, so far as they relate to the cities of Salem and Beverly, was that those two cities could most wisely supplement their present supply by pumping at time of flood flow from the Ipswich River into Wenham Lake.

Following the report of this special commission in 1913, the legislature passed an act creating the Salem-Beverly Water Supply Board, consisting of three members, two of whom were to be the heads of the departments of public works of the two cities and the third a non-resident of either of said cities, who was to be appointed by the governor. Under this act the board has proceeded with the carrying out of the work to date. The general purpose of the act was to authorize the securing of an additional water supply for the cities of Salem and Beverly by taking water, under stated restrictions as to time, quantity, and minimum flow in the river, from the Ipswich River at a specified point in the town of Topsfield, to Wenham Lake; to authorize the purification of the entire supply of the two cities when required, and to authorize if and when required the construction of storage reservoirs in order to increase the quantity of water which might be taken from the river under the conditions stated in the act.

The restrictions above mentioned are as follows: The total amount of water taken from the Ipswich River in any one year shall not exceed 2 500 million gallons. Water may be taken only between December 1 and June 1. Water may be taken only when the flow in the river is 20 million gallons a day or greater.

It was left entirely to the board, subject to the approval of the State Board of Health, to determine the details of the project.

The board had for its guidance the reports previously submitted, but the data upon which these reports were based were not complete enough for the board to determine the best and most economical scheme for providing the additional supply.

The board thereupon retained the services of Hazen & Whipple to investigate the various phases of the problem, which included principally the questions of diversion, of storage, and of filtration. A comprehensive topographical survey was at once begun. This survey covered about 9 000 acres, largely in swamp. The work was done in the winter, while the swamp was frozen. The survey yielded information which enabled us to set forth several different plans for storage in the river valley itself, and other prospective storage sites near at hand, and several different methods and routes for bringing water from the river to the lake, the best one of which resulted in a large reduction from the estimates that had been made for the probable cost of the additional supply.

Some years ago the suggestion was actively considered of including the city of Salem in the Metropolitan Water Supply system. If this had been carried through, some arrangement would probably have been arrived at between the cities of Salem and Beverly which would have given Beverly the rights now owned by Salem in the water of Wenham Lake and would have made unnecessary any diversion for either of these cities at present from the Ipswich River. This proposal was, however, rejected by the legislature of 1913 in favor of the plan for diversion from the Ipswich River, after an investigation and report by a special commission.

The entire question of storage of water in connection with the increase of the supply was considered at length. The surveys made covered all the favorable storage areas in and near the lower part of the Ipswich valley. Preliminary plans and estimates were made and reports prepared upon this whole question. From all the conditions, however, it is obvious that the larger storage projects are for the rather distant future; and the smaller ones, while they may be needed before many years, are not imperative at once.

Emphatic attention may also properly be called to the fact that, if some of the restrictive conditions in the act governing the

taking of water could be modified, the addition of further storage to the system could be postponed for many years. None of the restrictions are based upon reasonable data, but seem to have been fixed rather arbitrarily upon the representations of persons whose interests did not lie principally on the side of public opportunity.

Efforts will undoubtedly be made in the future to secure a reasonable modification of some if not all of these restrictions, in order to take advantage of large flows that occur from time to time throughout the year, but that will continue to run unnecessarily to waste so long as the act with its present wording remains in force.

The act of 1913 specified the point of diversion from the river to be in the town of Topsfield not more than 3 000 ft. easterly of the Newburyport turnpike. The records do not show clearly how this limit was fixed. It is supposed that it was fixed thus with the intention of placing the intake above the brook which runs down through the town of Topsfield. If this supposition is correct, some error was made, because the polluted brook just mentioned runs into the Ipswich River several hundred feet above the point of intake authorized in the act. Since the extension of the intake up the river was very expensive, and entirely unnecessary from the point of view of the hydraulics of the system, and since, moreover, there did not seem to be any practical advantage or any greater assurance of a satisfactory supply by carrying the intake above the outlet of Topsfield Brook, the exact point of diversion became a matter of prime importance.

An appeal was, therefore, made to the legislature of 1914 for authority to divert the water at a point much further downstream than stated in the act of 1913, but although this measure was well supported by the representatives of the two cities, Salem and Beverly, before the Legislative Water Supply Committee, the act was not passed, due, presumably, to the opposition of interested parties in the towns of Wenham and Topsfield. Later on, in 1915, after the plans had already been prepared for carrying out the greater part of the project in accordance with the act of 1913, the legislature was again petitioned for authority to locate the intake some distance below the point specified in the act of

1913. This petition was successful and a bill was passed amending that portion of the old act. The plans had been prepared with a view to anticipating this amendment, but could have been very easily modified to provide for carrying the intake upstream in case the amendment had not been secured.

The principal condition specified in the amending act was that the Salem and Beverly Water Supply Board should assume all the expense of changes or improvements that might be deemed necessary within the watershed of the Topsfield Brook, in order to properly protect from pollution the supplementary supply thus drawn for those cities. In compliance with this provision, remedies are now being applied for a number of nuisances and points of pollution in this region.

The plans for the works for the diversion of the water for increasing the water supplies of Salem and Beverly were prepared by us in the fall of 1914. The primary requirement in this design was to provide means of getting large amounts of water in a short time from the Ipswich River into Wenham Lake within the restricted period, and when the river was in flood, in order that the maximum benefit might be secured every year of all the storage capacity of Wenham Lake.

The problem of getting this auxiliary supply from the Ipswich River to Wenham Lake presented some interesting possibilities. All the projects heretofore proposed had been based on pumping from the river through long lines of pipe. Most of these projects had not assumed the rigid restrictions as to time, quantity, and river flow which were required by the act of 1913. These restrictions necessitated a design which would permit the delivery of a large quantity of water in a short time from the river into the lake. Long pipe lines of large capacity cost a great deal, and we naturally tried to find some means of avoiding this. A swamp of large extent lies between the river and the lake. This swamp is so flat as to give the impression of being dead level. It actually slopes several feet in its width, but the general flatness thereof suggested the feasibility of a canal as a cheap means of conveying a large quantity of water some two miles from the river to the edge of the swamp nearest Wenham Lake. This possibility was considered at various angles in comparison with several pipe line

projects, and the plans as generally outlined below were finally adopted.

The plans provide for taking the water from the Ipswich River just below the bridge of the Newburyport branch of the Boston & Maine Railroad, a short distance south of the village of Topsfield. From that point the canal extends in a southeasterly direction across the swamp a distance of about 10 000 ft. This canal is to have a bottom width of 20 ft. at an elevation estimated at 4 ft. below extreme low water in the river. The material through which the canal is dug is swamp muck underlaid by very fine sand. The material as removed from the canal is to be placed about equally on the two banks, leaving a berm of 10 ft. The banks are to be left approximately flat on top, in order that a road may be built later if desired at a minimum of cost. The average depth of cut for this canal is about 9 ft., and the maximum about 13.

The specifications provide that the dredge used for this work is, at the completion of the work, to become the property of the Salem-Beverly Water Supply Board, which will thus enable them to maintain the canal in good condition from year to year.

The accompanying picture shows the dredge at work and shows to some extent the nature of the material. Much of the area was at first covered with trees and underbrush, which were largely cleared off along the line of the canal before dredging commenced. This work was done in the winter of 1914–15, while the surface of the swamp was frozen. The contract for the work was let in the early spring of 1915 to F. T. Ley & Co., of Springfield, Mass., and the work is now well advanced towards completion.

At the southeast end of the canal lies the pumping station. The equipment at present is to consist of one centrifugal pump with a capacity of 25 million gallons per day, to be driven by an electric motor. The floor of the suction well for this pump extends down slightly below the bottom level of the canal. The structure, which is of massive concrete reinforced with steel, is provided with suitable racks, screens, and stop logs. It is designed for a capacity considerably greater than the pump now installed. Provision is also made in the pump-room for the installation of another pumping equipment of capacity at least equal to that now

installed. The power for operating the pump is to be furnished under an agreement with the Beverly Gas and Electric Company.

From the pump the water discharges through a 48-in. Venturi meter into a conduit leading to Wenham Lake. The length of this conduit is 2 866 ft. About 1 415 ft. of this lies practically level on high ground, limiting the height to which water has to be pumped from the canal; 1 406 ft. of the remainder lies on a slope falling rather sharply to the south from this high ground into Wenham Lake, and the carrying capacity required was, of course, obtainable on this steeper slope with a smaller size of pipe. This part of the conduit is, therefore, only 36 in. diameter. The 48-in. conduit and the greater part of the 36-in. are of concrete pipe, which was made on the ground by the Lock Joint Pipe Company. In the 36-in. line, a portion of the conduit crosses a swampy area, and some 411 ft. across this swamp was of cast-iron pipe laid on pile bents. At the point where the pipe discharges into Wenham Lake the bank is to be protected to prevent washing. The lift at the pumping station is estimated to average about 20 ft. for a flow of 25 million gallons per day and for the average stage of the river that is likely to obtain when pumping is permissible.

The system is simple in design and should be quite economical of operation. The large capacity required by the restrictions of the act will enable Wenham Lake to be filled rather quickly when the conditions of flow in the river permit. The whole number of days of operation in a year will, therefore, be small and a good opportunity is presented to arrange for the operation of the works at very low cost. The removal of some of the restrictions placed upon the diversion of water in the act of 1913 would enable the present works to serve without further additions for supply, and at very low cost of operation, for many years to come.

The cost of the work is now estimated about as follows:

Clearing wooded land, 26 acres	$2 800.00
Dredge	7 000.00
Canal excavation, 110 000 cu. yd., at 15c	16 500.00
Supplementary canal excavation, 9 000 cu. yd., at 22c	1 980.00
General excavation, 9 500 cu. yd., at $1.00	9 500.00
General excavation, 2 850 cu. yd., at $1.25	3 562.50
Concrete, 263 cu. yd., at $8.50	2 235.50
Steel reinforcing, 8 090 lb., at 4c	323.60

FIG. 1.
THE DREDGE AT WORK.

FIG. 2.
THE CANAL.

48-in. concrete pipe, 1 415 linear ft., at $5	7 075.00
36-in. concrete pipe, 995 linear ft., at $2.90	2 885.50
Laying cast-iron pipe on piles, 411 linear ft., at $5.80	2 383.80
Pumping station superstructure	1 805.50
Paving, 70 sq. yd., at $1.25	87.50
Construction under roadways	75.00
Appurtenances	1 500.00
Venturi meter and steel pipe	1 478.00
Cast-iron pipe and specials	3 000.00
Centrifugal pump, electric motor, and primer	4 090.00
Private transmission line	250.00
Switchboard and wiring	1 052.00
Other work and materials necessary to complete the work, not covered in above contracts	4 000.00
Total	$73 583.90
Land and right-of-way	14 400.00
Engineering and contingencies, about 15 per cent.	11 016.10
Total estimated cost of work	$99 000.00

DISCUSSION.

MR. L. M. HASTINGS.* Mr. President, I would like to ask how much increased storage capacity you will get by this scheme.

MR. LONGLEY. You get no increase in storage capacity, excepting as the pumping stations of the two cities may increase it themselves by changing the suction arrangements at their pumping stations in order to draw the lake down to a lower level. But the diversion of water from the Ipswich River does not afford any increase in storage excepting that it insures a full lake on the first of June every year, which we have not always had before.

MR. HASTINGS. Then, to put the question in another way, how much difference is there between a full level and a low level of Wenham Lake?

MR. LONGLEY. The lowest that the lake has ever been drawn, if I remember the records correctly, is something like 14 ft. below the full lake, and that 14 ft. gives a storage of about 900 000 000 gal. It has never been as low as 14 ft. at the end of the spring

* City Engineer, Cambridge, Mass.

rainy season. I think the lowest it has ever been at that time has been something like 6 or 7 ft., although I have not the exact figure in mind. There will be a benefit to that extent, and that, of course, is a very marked benefit. That insures, to a large extent, against dry years.

MR. D. W. FRENCH.* I have very much enjoyed Mr. Longley's interesting paper, as it compares favorably with some of the experiences the Hackensack Water Company have had during the last two or three years in preparing several hundred acres of heavily timbered swamp land for a reservoir site and to be excavated by means of hydraulic dredging. About 75 per cent. of the acreage was timber, with some very large trees, and we were confronted with a problem of how best to get rid of the stumps. Before starting the work we visited the dredging work along the New York State Barge Canal, thinking their experience might be helpful, and to some extent it was, although their line of survey had evidently been made, avoiding, just so far as possible, troubles of this character.

After experimenting considerably, we resorted to the use of 45 per cent. dynamite, which we found to be the most satisfactory, and, after blasting, using machines to pull the stumps and their fragments into large piles, and with the use of some oil succeeded in burning them.

After hearing this paper I was interested in knowing how the stump problem had been handled by Mr. Longley, and if his method had been any better or more economical than ours.

After overcoming the stump problem, ours was a case of dredging some 460 acres, the elevation of which was 14 ft. above mean high tide. Between 75 and 80 per cent. of this acreage has been dredged to zero, so that we now have within this area, 14 ft. of water.

MR. LONGLEY. The removal of the stumpage, Mr. French, is a very simple matter. The clearing simply consisted in cutting off the trees a foot or so above the level of the swamp, and that was done in the winter-time, when the swamp was frozen, which is about the only time we can get access to it. Then when the dredge came through it simply dug away at the toe of the bank

*Superintendent Hackensack Water Company, Weehawken, N. J.

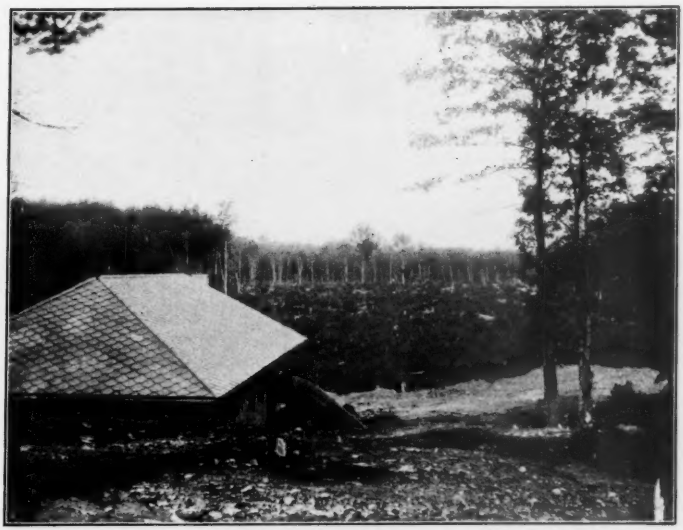


FIG. 1.
THE PUMPING STATION.

FIG. 2.
OUTLET ON CONDUIT AT WENHAM LAKE.

ahead of it and the stumps were undermined by that process. Most of the stumps, especially the small ones, came out of themselves. A number of the big stumps have had to be chopped loose from the ramification of small roots, but in no case have they given any serious trouble. We did not have the problem of rooting them up in the same way you had. We dug out from underneath. As far as the disposition of the stumps from the canal is concerned, they were simply thrown over on the banks and covered up by the mud.

MR. JAMES W. BLACKMER.* Mr. President, one point might interest the convention in regard to the cost of the excavation of the canal. Will Mr. Longley tell us the figures that were obtained for doing the work; I refer to the extremely low bid and the extremely high bid, as we thought.

MR. LONGLEY. I cannot quote them from memory, Mr. Blackmer. There was a great variation in the totals of the rather numerous bids, and that variation came largely in the canal figures. The final contract price was 15 cents a cubic yard in addition to the cost of the dredge itself, which was a separate item. The actual cost of excavation, not including any rental of the dredge from the best information we have, does not exceed 12 cents a cubic yard. We haven't very complete information on that, but that is in a general way about what the actual cost has run.

* Superintendent of Water Works, Beverly, Mass.

IMPROVEMENTS TO THE WATER SUPPLY OF THE CITY OF FALL RIVER.

BY H. K. BARROWS, CONSULTING ENGINEER, BOSTON, MASS.

[*Read September 9, 1915.*]

The water supply of the city of Fall River is obtained from the North Watuppa Pond, a large natural pond, about 1 800 acres in area, located just easterly of the city, with high-water mark at elevation 129.5 ft. above high water in Mt. Hope Bay. Water is taken at the west shore of the pond near the foot of Bedford Street and pumped into four large steel tanks, located at different sites in the city, but with overflows all at elevation 305, with a total storage of about five million gallons. Thence the city is supplied through the usual system of pipe mains.

On January 3, 1870, the mayor in his inaugural address called the attention of the City Council to the importance of supplying the city with water, and as a result of his recommendation a committee was appointed to investigate and report upon the matter. This report made to the City Council in August, 1870, included a report by Prof. John H. Appleton, of Brown University, who stated that the water of the North Watuppa Pond was eminently suited for purposes of water supply.

On November 29, 1870, the city purchased the land which is now the pumping station site, on the west shore of the pond, — about 48 acres.

The first Board of Water Commissioners was elected by the City Council on May 8, 1871, and during the next two years the present main pumping station was built, the pumping engine installed, and water mains laid throughout the city. The plant was put into operation January 5, 1874.

During the first few years the income of the Water Department was small, and for many years the city contributed annually to the expense of its operation. No direct appropriation has been made by the city to assist the Water Department since

1897. For the year 1914 the gross receipts were about $244 000, and the Water Department is the most important department of the city.

The immediate control of the Water Department is in the hands of a board of three water commissioners, a superintendent, a registrar, and various other subordinate officials.

As the North Watuppa Pond and its drainage cover a large area, it became necessary many years ago to give attention to the pond and its adjacent shores, with a view to maintaining the purity of the water supply. To place this matter under definite control, in 1895 the Reservoir Commission was established, which includes the three water commissioners, the mayor, and the city engineer. Since that time a large portion of the land bordering on the shores of the North Pond has been purchased by the city through the Reservoir Commission, and the improvements in the water supply with respect to its quality and adequacy now going on and projected are under the immediate direction of this commission.

Action in regard to the use of the water of the North Watuppa Pond by the city of Fall River began with the Water Act of 1871 passed by the legislature, giving the city the right to take the water of North Watuppa Pond for public and domestic purposes, and under the authority of this act the city elected to take 1 500 000 gal. per day. Under this act the city was required to furnish a reliable means for measuring the amount of water taken, and this has been done since that time, so that accurate records of the amount of water used by the city are available subsequent to 1873.

As a result of this act, in 1880 the Reservoir Company and the mills brought suit against the city for damages sustained by the taking of 1 500 000 gal. per day from the pond, and damages to the extent of $70 000 were awarded.

In 1886 the legislature granted the city the right to draw 1 500 000 gal. per day in addition to that previously authorized, and under this act the city was not held liable to pay damages sustained by any holder of titles and privileges. A bill was filed in the Supreme Judicial Court by the Watuppa Reservoir Company, claiming this act to be unconstitutional, but in the opinion of Chief Justice Morton in the celebrated "Fall River Water

.Case " of 1888 their bill was not sustained. In this opinion it was thought by the court that " the state had the right to use the waters of the great ponds for public purposes and to confer upon cities and towns the right to use the waters without making compensation to the littoral proprietors or to those owning land or water privileges on any stream from the ponds who may be damaged by such use."

In 1891, however, the Watuppa Reservoir Company again appeared in court with regard to the legislative act of 1886 and asked for an injunction to operate against the city. The court reversed the previous opinion, sustained the bill of the Reservoir Company, and issued them an injunction. It was established in this latter action that the plaintiffs were successors in title to grantees of Plymouth Colony, to whom the land under and on both sides of the outlet of the pond and of the Fall River (now Quequechan) was conveyed on March 5, 1680, to Church, Gray, and others for £1100. This grant was known as the " Pocasset Grant " and included all of the South Pond and about half of the North Pond. Consequently the state could not legally delegate to the city the power to draw off the waters of the North Pond to the detriment of the Reservoir Company.

In 1892 an agreement was entered into by the city and the Reservoir Company which has served ever since that time as the basis for use of water by the city. Briefly, it gives the city the opportunity to draw water from the North Pond for purposes of water supply, and only limits the use of water by the Reservoir Company and mills when the water in the South Pond has reached a certain minimum level.

On December 6, 1897, the city took by condemnation the entire North Watuppa Pond, including all the islands in the pond and the land under the pond, for the purpose of preserving and protecting the purity of the water supply, without, however, increasing the amount of water to be taken and used by the city except in conformity with the terms of the agreement in 1892 with the Reservoir Company.

Stringent regulations in regard to the protection of the pond for water supply purposes were made by the State Board of Health in 1907 and have been in force since that time.

The legislative act of 1909 authorized the city to borrow money for the construction of works and protection of its water supply, and it is under this act that the construction of the intercepting drain along the west shore of the pond, to be described later, is now being carried on.

The later legislative acts of 1913 and 1914 are broader in their scope and cover the matter of improving both the North and South ponds and abating nuisances along the Quequechan River. Under these later legislative acts another city commission known as the Watuppa Ponds and Quequechan River Commission is making an exhaustive study covering particularly the improvement of the Quequechan River and South Watuppa Pond, and under the act are to report to the City Council before October 1, 1915.

It will be noted that the city has full power to protect its water supply from pollution, but that the use of the water in the North Pond is shared jointly with the Reservoir Company in accordance with the agreement of 1892, which has been in force since that date. This practically means that the city is entirely at the mercy of the Reservoir Company in respect to the drawing down of water in the North Pond, so that under present conditions storage of water from year to year for purposes of assuring a sufficient water supply is not possible.

The present pumping station has been in use since 1874. It is built of Fall River granite and located on the shore of the North Pond at the foot of Bedford Street Hill. The original pumping engine had a capacity of 3 000 000 gal. per day; during 1914 the equipment is shown in Table 1.

In the earlier days it was intended to have both low and high pressure service; separate standpipes of small diameter were accordingly arranged at the top of Bedford Street Hill for this purpose. In 1886, however, this idea was abandoned and since that time the water level in the tanks or standpipes is at the same elevation in all cases.

At present there are two tanks, each holding about 1 400 000 gal., at the top of Bedford Street Hill, and similar tanks of about the same capacity, one at Townsend Hill in the southerly part of the city and another at Haskell Street in the northerly portion.

TABLE 1.

FALL RIVER MAIN PUMPING STATION. PUMPING EQUIPMENT, 1914.

Pump.	Kind.	Began Operating.	Cylinders, Diameter. Inches.		Stroke. Inches.	R.P.M.	Rated Capacity. Gals. per Day.	Duty. Million Ft.-Lb.
			Steam End.	Water End.				
Worthington No. 1	Horizontal, compound, condensing, duplex, double acting.	1875	29, 50¼	22, 22½	48	10	5 000 000	65
Davidson.....	Horizontal compound, condensing, simple, double acting.	1895	26, 48	24	36	20	4 000 000	65
Worthington No. 2	Horizontal, triple, expansion, condensing, duplex, double acting with compensator.	1909	21, 33, 60	24½	36	25½	10 000 000	135

NOTE. — All pumps operate under about 70 lb. pressure. Boiler equipment consists of four Hodge horizontal return tubular, each rated at 150 h.p. under 150 lb. pressure.

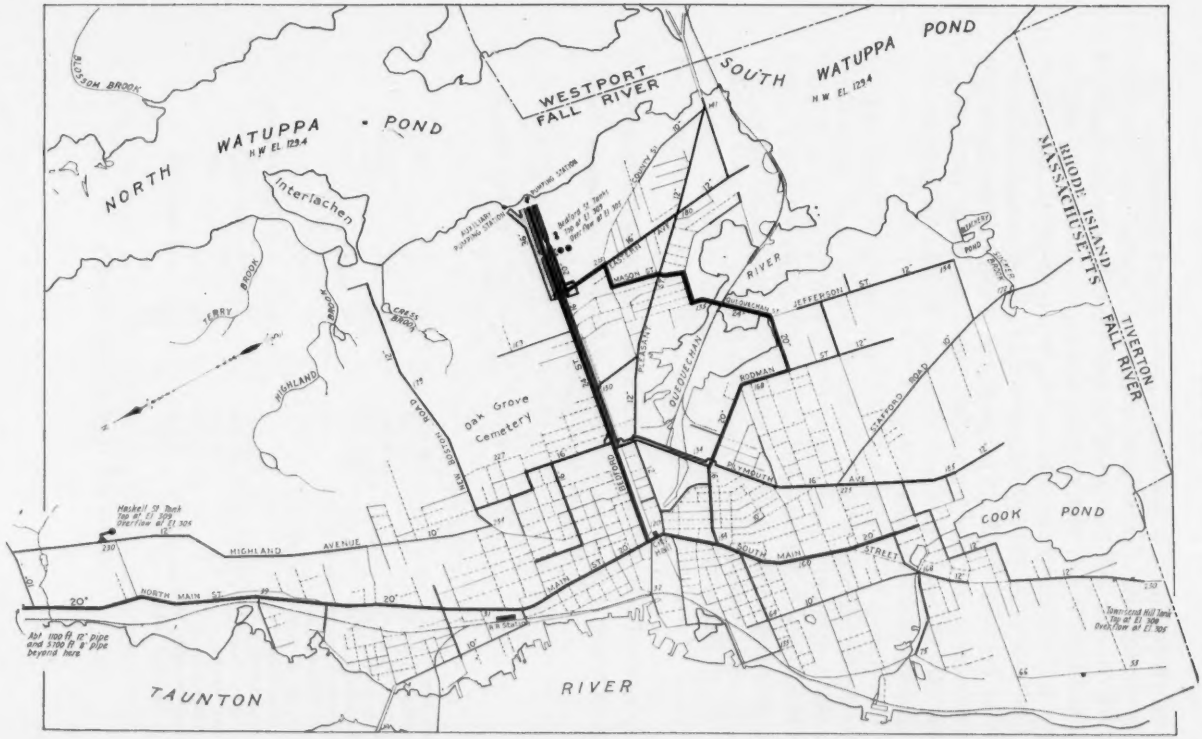


FIG. 1.

CITY OF FALL RIVER WATER SUPPLY SYSTEM, 1914.
Scale about 1 ft. = 10 miles.

NOTE: Figures thus, 230, show elevation above mean high water.

The total capacity of these four tanks is about 5 300 000 gal. As the city uses water at the present time at an average rate of about 5 600 000 gal. per day, it will be seen that the storage capacity of the tanks is very limited, being less than an average day's use. For many years in the reports of the Water Board recommendations were made for the construction of a large storage reservoir on Bedford Street Hill. The great cost of this has prevented its construction, and the city finally adopted the policy of building the cheaper steel tanks and providing a sufficient number of pumping units for a safe supply.

The principal pipe mains of the system, as will be noted on the accompanying plan (Fig. 1), radiate from the 24-in. and 16-in. mains in Bedford Street, varying in size from 24 to 12 in. in the principal streets. These mains are in general laid out with a view to providing ample water for fire protection purposes at the many large cotton mills located in and about the city.

TABLE 2.

CONSUMPTION OF WATER PER CAPITA IN VARIOUS CITIES OF UNITED STATES.

(From Report of Committee on Water Consumption, New England Water Works Association, March 12,* 1913.)

City.	Population.	Water Consumption. Gallons per Capita per Day.	Per Cent. Metered.
Saginaw, Mich.	51 510	186	6
Peabody, Mass.	15 721	168	..
Boston, Mass.	670 585	130	12.5
Milwaukee, Wis.	373 857	112	98
Cambridge, Mass.	104 837	101	30
Average 35 cities and towns in Massachusetts	.....	82	..
Average 17 cities and towns near Boston	.....	69	61 (18 to 100 %)
Providence, R. I.	246 000	63	89
Lowell, Mass.	106 294	51	79
FALL RIVER	119 295	44	99
Middleboro, Mass.	8 214	42	..
Marlborough, Mass.	8 202	37	65
Bridgewater, Mass.	11 051	22	..

* JOURNAL N. E. W. W. A., XXVII, 29 (1913).

The advisability of the use of service meters was early recognized in Fall River, and the efforts of the Water Department to reduce waste and misuse of water have been such that at the present time the per capita consumption is low. Practically all services are metered and the present per capita consumption is only about 44 gal. per day. This is seen to be very low as compared with other cities, as will be noted by reference to Table 2.

The Water Department has made special effort to eliminate leakage and waste of water. In 1897 this matter began to receive systematic attention by the department, and a comparison of the amount of water from which revenue was received and of that unaccounted for in 1913 as regards similar data for 1897 (see Fig. 2, taken from 1897 and 1913 annual reports of Fall River Water Department) will show the progress made in this direction. In 1913 about 60% of the entire amount pumped was sold to purchasers, about 12% was unaccounted for, and the remainder used for public purposes, bringing no direct revenue to the Water Department. When it is considered that an amount of water

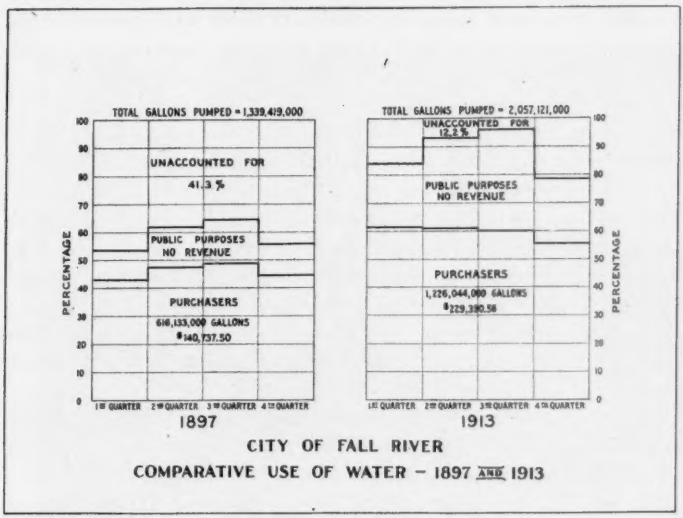


FIG. 2.

unaccounted for of 25% is in general regarded as satisfactory, it will be seen that the efforts of the department have been effective.

During the past year an old Davidson pump at the main pumping station has been replaced by a high-duty pump of 6 000 000 gal. per day capacity when operating under 70 lb. pressure. This has been built by the Platt Iron Works Company, is of the crank and flywheel type, horizontal, cross-compound, condensing, duplex, double-acting. Cylinders are 21 and 44 in. diameter at steam end, and $15\frac{3}{4}$ in. at water end, stroke 36 in., 36 rev. per min. The guaranteed duty was 140 million ft.-lb. per 1 000 lb. of steam. This pump has only recently been put in operation and has not yet been officially tested.

With the small amount of storage available in the four steel tanks, it was realized that a serious accident at the main pumping station might temporarily cut off the water supply to the city and result in great damage. Among the improvements carried out during the past year has, therefore, been the construction of an auxiliary pumping station located about 700 ft. northerly from the main station on the shore of the pond. This consists of a single story (and basement) station of brick with granite trimmings, about 25 ft. by 30 ft., with reinforced concrete roof and floors. (Plate III, Fig. 1.)

Water is brought to the station through a concrete intake extending about 70 ft. into the pond and terminating in a brick intake house containing a mechanically operated revolving screen.

The equipment installed at the present time consists of an 8 000 000-gal. per day motor-operated single-stage centrifugal pump made by the Wilson-Snyder Company. (Plate III, Fig. 2.) This is operated by a 350 h.p., 1 180 rev. per min., alternating-current, 3-phase, sixty-cycle, 4 000-volt motor, current to operate this being supplied by the Fall River Electric Light Company, so that the motive power of this station is entirely independent of that at the main pumping station.

The guaranteed efficiency of this unit under ordinary running conditions is 75%. This equipment has recently been put in operation, but has not yet been tested.

To still further make this auxiliary equipment independent of that at the main pumping station, a new 36-in. cast-iron main has

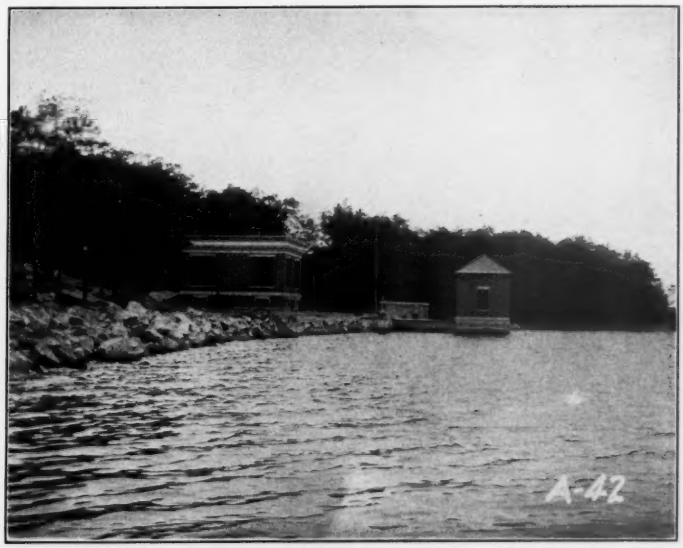


FIG. 1.

FALL RIVER AUXILIARY PUMPING STATION AND INTAKE.

FIG. 2.

FALL RIVER AUXILIARY PUMPING STATION.
8 000 000-gallon centrifugal pumping unit.

been laid between the auxiliary station and the tanks at the top of Bedford Street Hill. This will also be available for use by the pumps at the main station. This 36-in. pipe is also being extended as far as Eastern Avenue, where at present a 24-in. pipe leaves the 24-in. main in Bedford Street, which leads directly to the city. The capacity of the entire system has thus been very materially improved.

At the auxiliary station, in the discharge line, is installed a hydraulic gate so that one attendant can have at the switchboard immediate control of the pipe line leading to the hill.

A motor-operated valve is also to be placed, controlling the outlet from the two tanks at the top of Bedford Street Hill by means of remote control apparatus located at the main pumping station. The purpose of this remote control valve is to provide for immediate shutting off of water in case of a break in any of the pipe mains between the pumping stations and the top of Bedford Street Hill.

The approximate cost of the improvements in equipment as noted above (not yet fully completed) is as follows:

Platt high duty pump, including foundations	$20 000
Auxiliary pumping station and equipment (including remote control valve, etc.)	32 000
36-in. force main (about 3 400 linear ft., largely through ledge)	44 000
	$96 000

The Reservoir Commission has made steady progress since 1895 in securing land adjacent to the North Pond and constituting its drainage area, and a large proportion of this is now owned by the city. (Fig. 3.)

On the west shore of the pond is a large tract of land to a considerable extent populated, and in some portions thickly populated, which it has been impracticable to obtain by purchase, and, acting under the approval of the State Board of Health, the Reservoir Commission has, under the act of 1909, taken measures to divert directly to the South Pond, by means of an intercepting conduit running close to the west shore of the North Pond, all the drainage on the west shore beginning with Terry Brook, including Highland and Cress brooks and land adjacent to the pond for the

remainder of the distance to Pleasant Street near the South Pond.

It is of interest to note that in the first published report of the Water Commissioners, dated January, 1875, they recommended the purchase of a strip of land along the west shore of the North Pond from New Boston Road to the Narrows for the purpose of

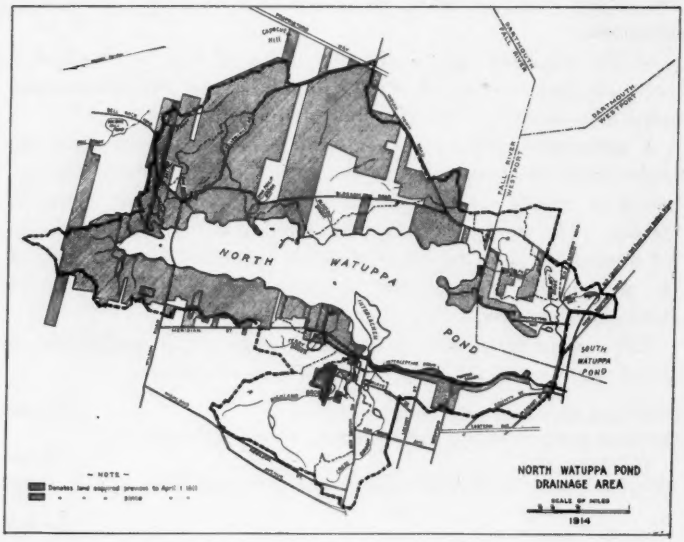


FIG. 3.

building a road and constructing an intercepting drain to prevent drainage from populated districts entering the North Pond. This was the first official suggestion in regard to the construction of this intercepting drain, and the contract for its construction was signed on January 28, 1915, almost exactly forty years from the date when it was first suggested.

The total drainage area tributary to the intercepting drain on the west shore of the North Pond is 2.32 acres. Nearly half of this consists of the drainage area of Highland Brook. (Fig. 3.) Adjacent to the pond, in the general vicinity of County Street, is a little over 0.5 sq. mile of area which in its southerly portion, between County and Pleasant streets, is thickly populated. Of

the total drainage area diverted to the South Pond, probably about one third is in a closely populated condition. The remainder of the drainage consists of grass and cultivated areas. Within the drainage are also two large cemeteries.

Between Terry Brook and Highland Brook, a distance of about 1 962 ft., the drain consists of a 24-in. vitrified pipe laid on a slope of 0.178 per 100, beginning at a small dam and headworks on Terry Brook at Meridian Street. The crest of this dam is at elevation 139.7, and the area flowed at this elevation is about eight acres. The ordinary flow, however, will be taken through a gate at such an elevation that water can be drawn down to about elevation 137.4.

At Highland Brook is a low concrete dam and intake, the crest of the dam being at elevation 139.5. From Highland Brook at Meridian Street to a point near the former channel of Cress Brook, a distance of about 1 500 ft., the drain is of standard 6-ft. open section, with the exception of two short stretches under Meridian Street and at New Boston Road, which are of 6-ft. covered section. This portion of the drain is laid on a slope of 0.0685 per 100. The 24-in. pipe from Terry Brook enters at the side of the 6-ft. open section a short distance below Meridian Street.

At Highland Brook intake the ordinary flow will be taken through a gate, the sill of which is at elevation 132.8. At the elevation of the crest of the spillway there will be a flowage of about 43 acres, and it is planned in the future operation of the drain to close this gate when necessary and hold water for short periods of time in the Highland Brook basin, to prevent overtaxing the capacity of the portion of the drain adjacent to the County Street area, which has steep slopes and will in time be closely built up and, therefore, quick spilling in its nature.

It is intended to divert Cress Brook at a point about 1 000 ft. from the pond directly into Highland Brook, so that advantage can be taken of the pondage at Highland Brook. This diverting drain from Cress Brook is a 30-in. pipe laid on a grade of 0.45 per 100 and was constructed by the Reservoir Commission prior to the time of letting the contract for the main drain, although the actual diversion of the brook cannot take place until the main drain is completed.

TABLE 3.

Section.	Length. Feet.	Size.	Slope per 100.	Capacity. Cu. Ft. per Sec. (Full.)	Total Drainage Area. Acres.	Capacity. Cu. Ft. per Sec. per Acre.	
						Without Pondage at Highland and Terry Brooks.	With Pondage at Highland and Terry Brooks.
Terry Brook to Highland Brook	1 962	24-in. pipe	0.178	10	140	0.07	.....
Highland Brook to Cress Brook (Sta. 105).....	1 576	6-ft. open	0.0685	125	1 120	0.11	.....
Sta. 104 to 79....	2 500	8-ft. open	0.0235	104	(1 150)	0.09	.....
Sta. 78 to 63± ..	1 500	10-ft. open	0.0235	145	(1 200)	0.12	.....
Sta. 63 to 58....	500	10-ft. covered	(0.0235) (0.104)	(145) (306)	1 240	(0.12) (0.25)	(1.2) (2.5)
Sta. 58± to 17±.	4 100	10-ft. open	0.104	306	(1 300)	0.24	.....
Sta. 17 to −1± ..	1 800	10-ft. covered	(0.104) (0.280)	(282) (462)	(1 385)	(0.20) (0.33)	(1.06) (1.74)

FIG. 1.

FALL RIVER INTERCEPTING DRAIN.
10-ft. open section. Arrangement of forms.

FIG. 2.

FALL RIVER INTERCEPTING DRAIN.
10-ft. open section near Station 72. Completed except grading of banks.

Below the old channel of Cress Brook the drain is of standard 8-ft. open section laid on a slope of 0.0235 per 100 for a distance of about 2 500 ft. For the remainder of the length (some 8 000 ft.) the drain is of 10 ft. section and for the greater part of open section. A short length under Bedford Street, and in the vicinity of the main pumping station is of 10-ft. covered section, as is also a length of about 1 800 ft. in the lower portion of the drain near the South Pond on Pleasant Street. The greater portion of the 10-ft. open section is laid on a grade of 0.104 per 100, although between Pleasant Street and the South Pond the slope is considerably steeper, 0.28 per 100.

In Table 3 are summarized data in regard to size, slope, capacity, etc., of the different sections.

It will be noted that this intercepting drain is of reinforced concrete and consists largely of open section work. This type of drain was decidedly more economical for a given capacity than a covered section. It also materially simplified the matter of the interception of all drainage from the pond and provides a positive cut-off or barrier that will effectively prevent any polluted water from reaching the North Pond.

The details of the various standard sections (with the exception of the 8-ft. open section) are shown on Fig. 4. (See also Plates IV and V.) To localize the effect of expansion due to change in temperature, and consequently of cracks in the concrete, a large amount, about $\frac{1}{2}$ of 1%, of steel reinforcement is used longitudinally, and this is placed in two rows of steel, one near each side of the concrete. The invert is of arched form, although this is obtained by means of chords rather than arcs of circles, in order to simplify the concrete work.

Provision for draining the side walls for a distance of 2 ft. from the top of the wall is made by broken stone filling for a width of 8 in. back of the wall. On the side away from the pond, at intervals of 25 ft., 3-in. tile pipe is set in the walls 24 in. below the top, for drainage purposes. On the side next to the pond no tile pipes are placed, but at occasional intervals drainage channels are provided so that water will not accumulate back of the walls near their top and thus cause danger of frost action and possible pushing in of the wall.

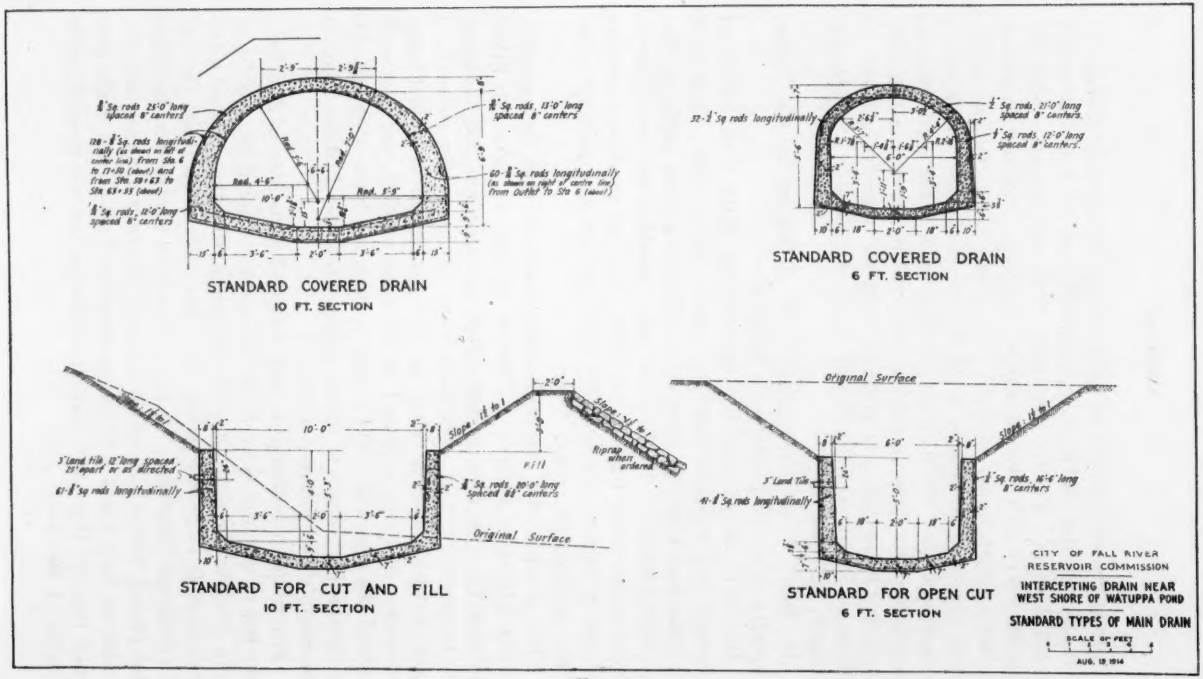

STANDARD COVERED DRAIN
10 FT. SECTION
STANDARD COVERED DRAIN
6 FT. SECTION
STANDARD FOR CUT AND FILL
10 FT. SECTION
STANDARD FOR OPEN CUT
6 FT. SECTION
Original Surface
Fill
Riprap where ordered
CITY OF FALL RIVER
RESERVOIR COMMISSION
INTERCEPTING DRAIN NEAR
WEST SHORE OF WATUPPA POND
STANDARD TYPES OF MAIN DRAIN
SCALE OF FEET
AUG. 13 1914

FIG. 4.

FIG. 1.

FALL RIVER INTERCEPTING DRAIN.
10-ft. open section near Station 44. (200 ft. radius curve.)

FIG. 2.

FALL RIVER INTERCEPTING DRAIN.
10-ft. covered section near South Watuppa Pond. In process of construction.

Great care is being taken in construction to obtain a dense and impervious concrete. The specifications provide for mixing in proportions "to be exactly determined from time to time by the engineer, in accordance with the relative coarseness of the aggregate," — the average relative proportions being from 1 : 2 : $3\frac{1}{2}$ to 1 : $2\frac{1}{2}$: 4. Frequent sieve tests of sand and broken stone are made to help govern the selection of the best proportions. Thus far the prevailing mixture for best results has been closely 1 : 2 : 4.

Bids were received on September 4, 1914, ranging in total amount from about $174 000 to about $240 000. Owing to the condition of the bond market last September [1914] it was not possible to sell bonds at par, and as this was required under the legislative act, there was a delay in awarding the contract until January 28, 1915, when it was awarded to the lowest bidder, the Hanscom Construction Company of Boston. They began work as soon as practicable in the spring and at present are making good progress, with more than 50% of the construction completed.

On the easterly side of the North Pond is a very considerable area, portions of which are quite closely populated, which must be diverted directly to the South Pond by an intercepting drain. This includes the drainage areas of the North and South Nat brooks and of Ralph Brook. Recent analyses made of samples of water at different places on these brooks indicate serious pollution and confirm the urgent necessity of this construction.

The general method of diversion has already been approved by the State Department of Health, the detailed plans for this work are now in process of preparation, and the work will undoubtedly be commenced as soon as practicable.

The total drainage area of the North Pond at present, including the area of the pond itself, is about 11.5 sq. miles. The intercepting drain on the west shore of the pond will divert directly to the South Pond about 2.3 sq. miles of drainage. The Nat and Ralph Brook diversion on the east side of the pond will take about 0.7 sq. mile more. The total area to be diverted is thus about 3 sq. miles, leaving for water supply purposes about 8.5 sq. miles of drainage area, of which 2.8 sq. miles is water area. The capacity of this 8.5 sq. miles of drainage area of water supply may be roughly estimated in the following manner:

For the average year the precipitation is about 47 in., and from measurements of the yield of the pond made covering two years, it has been found that about 50% of the precipitation is available as yield, the remainder being used up by evaporation, the demands of vegetation, and other losses. On this basis the total amount

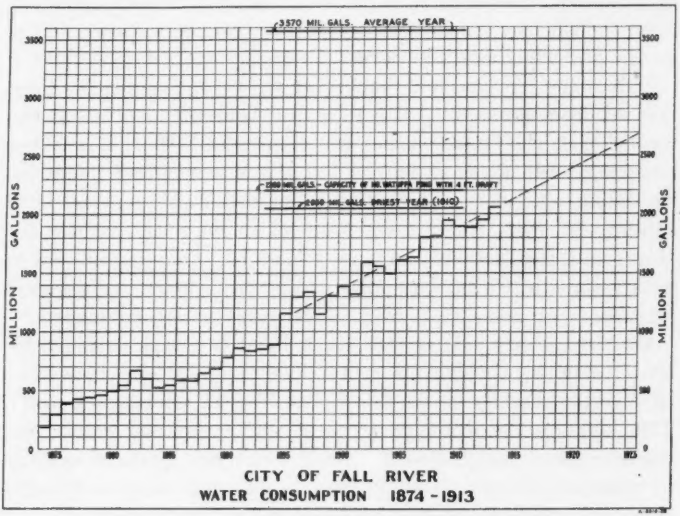

3370 MIL. GALS. AVERAGE YEAR
2000 MIL. GALS. DRIEST YEAR (1910)
MILLION GALLONS
MILLION GALLONS
CITY OF FALL RIVER
WATER CONSUMPTION 1874 - 1913

FIG. 5.

of water available for the average year would be about 3 460 million gallons. In a dry year like 1910, when the precipitation was about 34 in., probably not over 40% of the precipitation can be utilized, or a total of about 2 000 million gallons. The total amount of water used by the city during 1913 was about 2 050 million gallons, and this amount is increasing from year to year, as will be noted by reference to the accompanying diagram. (Fig. 5.)

This approximate analysis shows that even at the present time storage of water in the North Pond would have to extend over more than one season in order to assure an adequate supply in a very dry year, after the diversion of drainage contemplated by the improvements now being carried on.

Under the present agreement, the Watuppa Reservoir Company can draw water from the North Pond without any limitation until the pond is at about 40 in. below "full pond." It is evident, therefore, that under present conditions the North Pond cannot be used by the city in storing water from year to year for water-supply purposes, and there is likely to be a shortage of water at any time after the diversion works are completed.

The additional problems before the Reservoir Commission are, therefore, first, to obtain for the city complete control of the waters of the North Pond, and, second, to supplement the water supply from some other source. To assure an adequate water supply these measures must closely follow the diversion improvements now under way.

DISCUSSION.

MR. FRANK L. FULLER.* I would like to ask what the city pays for the current which they use for the centrifugal pump.

MR. BARROWS. The cost of power for pumping is in accordance with a sliding scale; the first 50 000 kilowatt-hours at 1½ c. per k.w.h., the next 100 000 at 1 c., the next 150 000 at 0.9 c. The new pumping station will be for some time to come used simply as an auxiliary station, at such times as the main station is shut down for repair or in case of emergency, consequently the rate paid will be nearer the upper portion of the scale.

MR. PERCY R. SANDERS.† I would like to ask how you get the figures for the water accounted for, shown on Fig. 2. Is the water used by the street sprinkling carts and the different city departments measured by meter?

MR. BARROWS. Certain of the public uses of water have to be estimated, as meters are not used in all such cases. These estimates are, however, controlled from time to time by tests or by the temporary installation of meters in order to insure that the estimates are reasonable.

---

*Civil Engineer, Boston, Mass.

†Superintendent of Water Works, Concord, N. H.

DETAIL METHODS USED IN THE FORESTATION OF WATERSHEDS.

BY SIDNEY K. CLAPP, ASSISTANT ENGINEER OF THE BOARD OF WATER SUPPLY, NEW YORK.

[*Read September 8, 1915.*]

The ordinary methods followed by foresters and nurserymen in the propagation of small trees from seeds are too well known to need any description. There are, however, various experiences which may be of interest if explained in detail.

The gathering of seed is one of the first points to be considered. A careful inspection of the cones or seeds on the trees will determine whether they are in a proper condition to be gathered; a change from dark green to brown is a good indication. A few hours is often sufficient to fully ripen the seeds, and a sudden gust of wind will spread them in every direction. A very unique and satisfactory method of gathering conifer seeds, has been used extensively at the Ashokan Reservoir of the Board of Water Supply, City of New York, where several hundred thousand trees are grown annually. At just the time when the seeds are ripe and the cones opening, blankets, sheets, and cloths are spread on the ground around the tree and the tree violently shaken; there should be no perceptible wind at the time. The seeds fall on to the cloths in a shower resembling a heavy snowstorm, and a considerable quantity of perfectly clean seed results with little effort. At other times it is necessary to pick the cones just before they open, storing them in burlap bags until they can be spread on proper racks to ripen and dry, when they are threshed and cleaned or winnowed.

After the preparation of the seed beds with their racks and the planting of the seed, which is described in several books and circulars on this subject published by the state and government departments, the real trouble begins.

The seed, being oily and nutritious, is much sought after by

mice and birds, which will destroy thousands in a very short time; even when they are well out of the ground, the birds will pick off the little seed cap, killing the tree.

After this experience with birds and mice comes the scourge called mildew, and thousands of small trees " damp off," when it is impossible to secure the proper sunlight to dry the ground sufficiently. Too much sunlight at such times will cause the small plants to " wilt " and die, so that a happy medium must be secured. It has been found that dry road dust will often prevent or stop mildew when no other remedy is available.

Considerable trouble is caused by a thin covering of green moss which grows on the surface of the ground and is at times almost imperceptible, but apparently saps the vitality of the plants, restraining the proper moisture and air from entering the soil. Some seedling trees, such as the hemlock, apparently are not affected to any extent, as this seems to be their natural environment. Dry road dust has been very effective in the treatment of this problem.

After the small trees have passed through the various overground scourges, they are often attacked from beneath the surface. You will be surprised at visiting your seed beds some morning to discover that quantities of small trees have grown suddenly shorter; their little leaves lie flat on the ground as if the roots had become deeply imbedded. If they are raised from the ground you will find that there is no stalk and the entire root has disappeared. If you sacrifice some of the trees in the immediate vicinity and dig up the ground to a depth of several inches you will invariably find either a small white grub half an inch long and about the thickness of the lead of a lead pencil, or a full-sized white grub as large as your finger and an inch or two in length. No spray or solution has yet been found which can reach these grubs without affecting the small trees. A method which was used to some extent in exterminating the large grubs was to make a comb out of hatpins spaced about one-half inch apart; thrusting these into the ground over the affected area, piercing the grub and killing it.

Even when the small trees are covered with burlap or evergreen boughs to prevent winter-kill, it is necessary to watch them, as

field mice will enter under the coverings and cut away the small trees, which they use for nests, leaving only the stubs. Sowing wheat and other grains soaked in strychnine throughout the beds before covering them is quite effective, but even with all this care the mice will sometimes attack the trees and in a few days do great damage.

Winter-kill is another source of danger, and this may occasionally be traced to the fact that the seed used came from a milder climate producing trees which are not hardy when grown in this region; hence it is important to be sure of the character and quality of the seed. In one instance several pounds of Douglass fir seed was ordered, and it was specifically stated that this should be "Colorado Douglass fir seed." A stenographer or the purchasing agent, in an endeavor to abbreviate, changed the word "Colorado" to "Cal.," which was immediately accepted by the seed agent to mean "California," and as such the order was filled. These California seeds were not hardy, and the result was that several thousand trees were winter-killed.

Spring is the busy time in the nursery. The two-year-old seedlings are carefully lifted, gathered in bunches, and their roots immersed in a thick solution of muck, of the consistency of soft tar. These are then carried to the men at the transplant beds. At every operation where a small tree is successfully moved it is necessary that the covering of the root be kept moist, and bog muck has at all times been a most efficient material.

Various methods have been tried out in planting trees in the transplant beds. Transplant boards, racks, and other devices were used but finally discarded. The method employed is as follows: A line is stretched lengthwise of the bed, which for convenience is made about 6 ft. by 50 ft. A square-pointed short-handled shovel, flattened on an anvil, is guided by this line and pushed deep into the ground and swayed from side to side, leaving a well-defined slot or groove. The planter follows immediately on one knee, and with a single operation drops the root into the soil, firming the ground about the small tree, and advances three or four inches, as the case may be, repeating the operation. The rows are about eight inches apart. With a little skill a man can plant about a thousand trees in an hour and have every assurance

that the roots are deeply imbedded and will not succumb to the subsequent dry-weather periods. This will also prevent in a great measure the heaving by the frost, which is so fatal to transplant beds in this region.

From a considerable experience with various kinds of seed, it is found that certain varieties are more hardy and better adapted to the soil and climate at hand. For this reason it is well to try a great many varieties before accepting any one or two as a basis for a large planting. The greatest part of the seed on the market is of foreign origin, is not true to name, and, when purchased by competitive bidding, may be poor and not worth the necessary trouble to grow. Our experience has been that it is far better to collect native seed from local sources than to run the risk of purchasing seed that is poor in quality, diseased, or unsuited to the climate. In one or two cases seed was purchased which took two years to germinate. This is true of some of the junipers, and it was remarkable to find not a seed coming up the first year, but a fairly good stand the second year. In another case seed was planted in the fall in the natural way, but the germination and subsequent growth was quite irregular and not as satisfactory as when planted in the spring.

It is often necessary to spray certain areas which become affected with the woolly aphis, a soft green worm or slug covered with a white exudation appearing like cotton. There is also a pine worm which is so nearly the color of the small trees that it is hardly noticeable until it has done considerable damage. These come in large numbers and work rapidly; they have been destroyed with tobacco or oil emulsions. The weevil, which destroys the leaders of larger pine trees, can best be checked by cutting and burning the affected branches several times during the season. To combat the white grub, the soil, which should be a light, sandy loam, has been treated with air-slaked lime and old plaster from buildings, also with salt; it has been cultivated several times during the year and various cover-crops tried; it has also been thoroughly plowed at intervals and just before heavy frosts, but with all these precautions there remain infested areas which it seems impossible to eradicate. It is also surprising to find that the grubs have a selection or choice, and that they will attack certain varieties of

trees, passing by or under other varieties for which they do not apparently have a taste. A very interesting experiment was tried by planting some of these trees, such as the Colorado blue spruce, for which the grubs have a particular liking, among trees of the native red pine. This, so far, has worked out very successfully, but it may not be entirely successful as the grubs will probably find the spruce before long and will then go through the entire row, doing great damage before it is discovered.

No success has ever been attained in fall transplanting from transplant beds to the open fields, and this should only be resorted to in case of necessity. In one case 99 per cent. of 20 acres of planting was winter-killed.

The greater part of the forestry work at the Ashokan Reservoir, outside of forest improvement, has been devoted to the raising and planting of conifer trees, because they are not as common as deciduous trees, present a pleasing appearance to the landscape, and act as a screen to the ground at all times of the year, although a considerable number of oaks and white ash have been successfully raised. Many of the old wood-lots which were littered with undergrowth, dead tops, and branches have been improved and thinned out, the better types among the trees being preserved for future forest stands.

(The discussion of this paper will be found on page 74.)

COSTS AND RESULTS OBTAINED IN REFORESTATION OF THE CROTON WATERSHED.

BY T. C. CULYER, ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK.

[*Read September 8, 1915.*]

Forest-tree planting on the city's watershed is a comparatively recent enterprise. The first attempt in the nature of elemental forestation by the Department of Water Supply, Gas, and Electricity was made in the spring of 1912, and was applied to portions of the extensive area of land owned by the city, which comprises a material part of the catchment areas in Westchester, Putnam, and Dutchess counties, in this state.

Its significance, if any, lies in the fact that it was a beginning where usually, as in most enterprises, it is the first step that counts. There have been, however, other and earlier undertakings of this nature hereabouts and in neighboring states, where the experience and results have proved satisfactory and have seemed to encourage and justify a continuance and decided enlargement of the work. That of the Board of Water Supply of this city carried on over territory under their jurisdiction at Kensico and Ashokan is notable for its extent and promising results. That department, fortunately, is in command of larger financial resources than the Department of Water Supply, and has a freer hand in using them for this laudable purpose. The work is being thoroughly done, to its future advantage and for the public benefit.

Owing to the fact that our planting operations cover a period of less than three years, sufficient time has hardly elapsed in which to have obtained, by observation and study, any substantial data, other than that, in a limited way, to be herein submitted.

You are probably familiar with what has been accomplished in and about the city of Boston, several years ago, by the Metropolitan Commission, over the denuded Blue Hill Reservation in particular. Here the purpose has been to renew and restore

indigenous vegetation to this reservation, covering a very large area, and upon which substantial trees and shrubs have been placed. The development and growth of this material has made satisfactory progress in large part over the whole area, and the visible results are already suggestive, to one familiar with its former run-down and unkempt condition, of lively promise of a renewal of the woodland effect and the wild verdure which in earlier days existed over this rugged and picturesque country.

The titular watershed constituting the source of water supply for the city of New York encloses a territory, partially extending into the state of Connecticut, of 362 square miles area. Within this, and confined to the counties of Westchester, Putnam, and Dutchess, the city has acquired and now owns some twenty-two thousand acres, wherein is contained numerous storage reservoirs, lakes and ponds, together with existing streams and other natural sources of water. For the purpose of this article, the land comprising the Catskill domain is not considered. The large quantity of land in excess of that occupied or required for storage purposes, dams, and other structural features, affords ample means for safeguarding the streams against pollution and other undesirable contingencies, which was the primary object of its acquisition. The course of this property is long drawn out, comprising divergent localities which form sites and protected areas for reservoirs and numerous streams, the natural eccentricities of which influenced the problem of its original taking. You will surmise, therefore, that we have, as in the Catskill and Blue Hill reservations, considerable units of land upon which to outline and carry on any formal forest renewal as a permanent feature of the landscape, or for ultimate commercial purposes. With this general limitation in view, we have planted in certain localities many trees on ground within and nearby the several villages within the watershed and about the dam sites where conditions permit, and in long stretches adjacent to the public roads. These trees, some of them three years old, are very promising in their growth, reaching a height of five feet or more in attractive characteristic form, and unquestionably have invited public attention and approval.

We have used three and four year old transplants consisting of white and Scotch pines and spruce, secured from the State

Conservation Commission. The cost of the plants for the first two years averaged $4.25 per thousand, but this spring they were supplied for fifty cents per thousand, the city, however, in both cases paying the express charges.

Close planting is generally recommended for reforesting work, the object being to secure straight stems and reduction in knot wood growth. The plants are certain to grow in open ground, on the removal of other surface vegetation. In preparing for planting, we removed the grass and other growth for a space of about two square feet, at the same time the hole was excavated for planting. Incidentally, this served as an additional safeguard against fire.

The work of planting proceeds as follows. The tree sites having been prepared, two men, constituting a planting gang, go upon the ground, one ready to plant, the other carrying a number of plants in a pail in which a sufficient amount of water is supplied to keep the roots of the plants moistened, and from which pail the plant is passed to the man who is to plant the tree. The cost of this proceeding has been one cent per tree, and it has so far proven reasonably satisfactory, since our loss during the three years' experience has been within fifteen per cent.

It will happen that, within some area with which you may have to work upon, there will not be available any land of considerable extent where you can consistently install the more formal system of forestation prescribed by the authorities. At the same time it may be feasible to plant the same class of trees irregularly in interrupted sequence in quite ample numbers, reinvesting the denuded border of streams and the environment of natural and artificial bodies of water which, without primarily designing to secure that object, will result in imposing upon an extended landscape an effective and attractive feature to the eye.

Our interest, as a people, in forestation has not been general, and, in comparison with its practice in other countries, has been only of recent and fitful concern, while in many states the subject as a serious economical problem is still dormant. Our belated reservations of vast tracts of land, still notable for its natural investiture, have prevented the destruction of an invaluable natural heritage, and these will be added to from time to time,

as the public becomes more intelligent regarding their value to the nation, and approve of the necessary outlay for their acquisition.

Concerning the cost of such work as ordinarily exploited, the figures indicate the attainment of considerable labor efficiency, and handling and planting of from one thousand to twelve hundred plants according to size by a team of two men has been stated as a usual day's work.

The plants at first cost being cheap, it is apparently assumed that comparatively superficial work in planting will nevertheless insure the growth of a substantial percentage, and therefore it is not worth while to deal interestedly with the individual plant. As to the possibility of properly placing one thousand to twelve hundred plants per day, by two men, I "have my doubts." In some of these localities, where this kind of enterprise is contemplated, there is a decided handicap facing the plant at the outset in the meager supply of soil for root covering and support. I believe it would pay, at a slight increase of cost per thousand, to supply a small additional quantity of good soil to each plant. It may be impossible to follow out this plan at present, but it is to be borne in mind that any plant whose body structure shows strength and characteristic development and whose roots are full and fibrous, even at the early stage at which the stock is supplied, if properly planted and thereafter given a fair chance, will replace in value a half dozen weakly or otherwise fairly grown ones which have suffered some impairing injury. This kind of vegetation shares many elements in nature, in common with human beings. They need and thrive on good food and suffer for the want of it, as they do for water or its lack.

However small the plant may be, in placing it permanently in the ground the excavation should be ample enough to allow a full spread of the roots. A small supply of good soil conveniently handy to the planter will enable him to make his work good at little loss of time, and these, as do all plants, will in their own mysterious way gratefully acknowledge a generous "meal ticket" in a more vigorous and promising development. Spring is regarded as the most favorable season for planting, though where a large number of plants are to be disposed of, the work may be successfully renewed in the fall months, until frost. Spring

planting has the advantage of preceding the growing season, during which the plant becomes established in the ground. The effect of drought in the beginning is the most discouraging experience of the young plant, at which time an artificial supply of water if possible is the one thing needful.

Evergreens seem to adapt themselves to most discouraging conditions, yet all like good soil, the better food supply.

The white pine, often growing vigorously in light sandy soil, will respond to good soil in the growth and substance of its timber. It is not adapted to wet ground.

On poor soil the Scotch pine, while less attractive in form and habit and not so valuable commercially, grows hardily, being aided in its efforts to thrive under somewhat adverse conditions by its longer penetrating root. In its native country, it is regarded as we regard the white pine.

Of the spruce, the Norway spruce is to be preferred to the native, and will do best in fairly good soil. It grows, too, better than most cone-bearing trees, in moist ground, and may be used to advantage for under-planting in existing woods. It is, in fact, noted for its hardiness and its adaptability to almost any soil.

The list of trees at present supplied by the state seems to be somewhat restricted. This may have been and is still due to the great demand for plants. It is certain, however, that if variety sometimes quite desirable is sought, there are, in addition to the above named, not a few trees that may be used, especially where the less formal and the more desultory manner of planting is possible. The hemlock is a beautiful tree, and should not be ignored, despite the fact that it is less valuable than most wood, but still profitably available for rough work.

The larch, too, notable for its fine standing timber, hardy and with a peculiar and interesting foliage, grows well in any fairly good soil. Other species of evergreen, including the juniper, of a rather dwarfish tendency of growth in conjunction with stocky low-growing under-wood, are excellent for the formation of thicket and for the borders of stream and pool, offering a fine harbor for birds.

In the matter of tree planting for shade, and the ornamentation of our public roads where conditions are suitable, as indeed they

generally are, if the engineer will give attention at the outset to so desirable an item in the project of road building as tree planting, there should be provided as an integral part of the specifications that trees shall be placed in properly spaced locations and seasonably planted. Under these conditions, the engineer will experience pleasure in having writ "*finis*" upon an enterprise which will retain a very effective feature and show an increasing value of the trees, secured, as he will be surprised to learn, at almost negligible increase of cost per foot of the whole undertaking.

If I may offer a suggestion, a sort of generalization, it is to say that the tree symbolically should constitute a subject of an awakened interest to the engineer, with whose endeavors and enterprises it is in so many ways associated. The engineer is, by virtue of his profession, assumed to be fairly equipped educationally, with normal capacity to comprehend and appreciate abstract and concrete art and science as ordinarily applied in human affairs. He has often been and is likely to be the pioneer and the companion of the pioneer in the successful venture and glory of original exploitations, especially in relation to enterprises where he is to discover at first hand the wonderful features of nature, the surpassing beauty of forest and field, and a surprising contrast of vegetation in all its varied forms. But he has not permitted himself to add practice to this natural and acquired equipment. He has been tethered to the principle generally accepted by the profession, that always his aim must be to build well, under eternally rigid exactions of economy, and prepare the way for others, as the architect, the gardener, and often the superficially equipped empiric, to deal with his creation with a free hand in expenditure denied to him, in applying those features of superficial external adornment, essential to its completion.

DISCUSSION.

MR. CALEB M. SAVILLE.* The watershed of the city of Hartford, located on the easterly slopes of Talcott Mountain, is about twelve square miles in area, of which between five and six are owned and controlled by the Hartford Water Board. Of that

*Chief Engineer, Board of Water Commissioners, Hartford, Conn.

five or six square miles, about 1 700 acres are in a naturally wooded condition, 885 acres in old pasture covered with sprouts and young growth, 85 acres upland used for growing hay, 485 acres water surface, and 230 acres plantation, mostly white pine. The area of old pasture is gradually being planted to pine, about 25 acres being put down in a year. We have had considerable trouble with the pine-tree weevil, which attacks the tops of the white-pine trees. We hope he is like the seventeen-year locust and is getting tired of work, and we will not hear of him again for a long time. We consulted several foresters in this matter, and are now planting red pine, which the weevil is said not to attack and which I am told is about as good for timber purposes. I noticed Mr. Clapp spoke of planting ash. We planted a great deal of ash in the first part of our plantation work, but the rabbits and deer destroyed so much that we have ceased to plant these trees. We plant nothing now but coniferous trees. The chestnut blight has so seriously affected the entire area of our watershed, and that part of Connecticut also, that probably the only remedy is the complete removal of the chestnut tree, and reforestation.

While it is possible theoretically to produce profits from thinning and clearing on forested areas, and most of the foresters whom we have talked with have assured us that we could expect such a profit, it is worth while to note that in our experience such profit is decidedly non-existent, because we have used pipe-laying gangs in the winter time who, while experts with pick and shovel, are not economical woodmen.

Mr. Edward E. Minor.* In New Haven we have been interested in forestry work for quite a number of years. We have a large territory which we own, do our own planting, and raise our own stock. We make a profit on our forestry work. Most of the lumbering work is done under contract on a percentage basis. We use our own men in the winter at times, but we find it unprofitable because they are not accustomed to lumbering work. It requires men who are used to that work to make a profit out of it, as the margin of profit is very small.

We are very apprehensive about fires. We spend a great deal of time in developing fire lines. I have not heard that spoken of

*Superintendent, New Haven Water Company, New Haven, Conn.

as yet. We divide our tract up into various districts and have these separated by lines which are cleared every year, and in the spring and fall we have a gang of men watching. They have a system of signals so that they can bring help if a fire starts. We seldom go through a spring or fall without having two or three very severe fires, which we are able by means of our preparation to control before they do material damage. We have about 1 200 acres planted at present, and are planting about 200 acres a year. The planting costs us about $7 an acre. The raising of tree stock costs us very little. A week's work every spring followed by occasional weeding covers all the work we do on our nurseries. We have to spend considerable time in June and July going over all our plantations and taking out the pine weevil. We are planting about half and half red pine and white pine. Some of our plantations are 25 to 30 ft. high, and are high enough to shut out all the underbrush, and certainly look encouraging. It is very interesting work and one, I think, that will not only bring profit but also the advantage of covering our watershed with trees which have beauty as well as a practical use.

MR. WILLIAM F. SULLIVAN.* Mr. President, Nashua is in Hillsborough County, New Hampshire, and this section of the state is a natural white-pine region. At the present time, on account of the browntail moth and gypsy moth, the stunted growth of deciduous and particularly of oak trees, and the long time it takes oak trees to mature, we do not consider the hardwoods of any especial value.

Our chestnut lots are affected with the chestnut blight, and we have been told by the state forester that we should cut all chestnut trees that show any signs of infection. I might say that our forest reservation was started about sixty-two years ago, when the water company first acquired land. And the water company has continued to acquire land ever since, primarily as a protection to its water supply. On some lots acquired, there were even stands of pine, some full grown. Other lots were sprout land, and some were pasture lands. We have done some planting on cut-over land. The planting was done not from seed, but from natural reproduction nurseries. From these nurseries we obtained the

* Engineer and Superintendent, Pennichuck Water Works, Nashua, N. H.

saplings, and planted them in open areas and on former grazing land. For years the company has thinned out and taken care of its forests, so that to-day we have arrived at the stage of being able to do lumbering operations. When we cut, we do it so that the cut-over strip will be to the southeast of full-grown stands or seed trees. As you undoubtedly know, this is for the purpose of having the seeds blow to the deforested tract, and if they take root there, seeds will reproduce naturally. We have some excellent examples of natural reproduction.

We are at the commercial stage of forestry. We have erected a water-power sawmill about midway of our reservation. We use our own men entirely in the operations from "stump to stick." We consider it profitable to use our regular crew in winter when very little pipe laying is being done, and thus keep our organization throughout the year. We may probably have some advantage over my friend from Hartford, and possibly some others, in that our foreman and laborers came from over the Canadian line, where in their youth they worked and logged in the woods, and are familiar with woodcraft. They are natural foresters.

For several years we have sawed our logs. This logging has been white pine and hard pine. The hard pine in our country is stunted in growth and not of as much value as white pine, but it makes good box boards, and we get a fairly good price for it. We have white pine of different grades, a large percentage being of first quality.

I will say it is my opinion, my strong conviction, that the planting of white-pine trees on land where they will grow, or the purchase of tracts which are coming up to pine, is a profitable venture, and will show a profit not alone for water companies, but for the farmer, for the firm, and for the individual. It is a proposition for any one with either large or small capital who is willing to let the investment remain over for a long period of years. By such an investment in white-pine growths, one is only putting the money so invested, with its increment, away for his children or his children's children.

MR. SAVILLE. I would like to say, Mr. President, that I personally agree with Mr. Sullivan that white pine is proper to grow on watersheds, and will perhaps warrant making it a commercial

success. At Hartford we are planting twenty-five acres a year, and expect to do it right straight along.

MR. SULLIVAN. Mr. President, the principal part of our reforestation is done by natural reproduction and from transplants from reproduction nurseries, as we call them. We have some excellent stands of transplanted white pine, from ten to twenty years of age, which are surprising. When trees show a diameter of 6 in., breast high, after twenty years growth, you will realize that white-pine trees have a value.

I will say regarding fires that we have been fortunate. We take the precaution to keep the slash and brush cleared and burned. The fire hazard in forests is not so great now as it was a few years ago. People in general realize the danger and loss there is from forest fires. The railroads are more careful. Sportsmen are careful after using matches and smoking. We maintain a patrol on Sundays and holidays. We have a private telephone from the pumping station to the center of our tract to enable the patrol to report any fire and call for help to extinguish it. We are also protected by wise forest fire regulations.

THE PRESIDENT. Is it not true, Mr. Sullivan, that you have built some roads through those woods which also tend to act as fire cut-offs?

MR. SULLIVAN. It is our purpose that all forest roads, in fact all roads through our land, should serve as fire stops. Logging roads which grow up with brush we plow and harrow so that there may be fresh earth. We have sixteen hand fire extinguishers ready and handy in an accessible place. We have an automobile truck in use for service work. This truck is provided with seats similar to the regulation fire patrol and is capable of taking on the extinguishers, shovels, etc., and a gang of from five to fifteen men. We have not had many fires, none serious, but our outfit has been of assistance to our neighbors, and by assisting them we have protected ourselves.

MR. WILSON FITCH SMITH.* Mr. President, in regard to the cost of planting, I might quote the experience at Kensico Reservoir. The city of New York has planted over 800 acres on the marginal strip around Kensico Reservoir during the past four

*Division Engineer, Board of Water Supply, New York City.

years with white, red, and Scotch pine and Norway spruce. In 1912 and 1913 the work was done by the employees of the Board of Water Supply. Three-year-old transplants obtained from various nurseries were planted in rows 6 ft. apart each way. During these two years, 551 000 trees were planted at an average cost of $12.38 per thousand. This cost includes the following:

	Average for Two Years per Thousand.
Cost of three-year-old transplants	$4.41
Freight on transplants	.43
Labor handling for inspection, and teaming	.50
Labor planting	6.30
Engineering supervision	.74
	$12.38

The labor was at the rate of $2.00 a day for an eight-hour day. These figures are the averages for two years' work. Toward the end of each season the men became more experienced, and planted about 500 trees per man-day.

For the purpose of obtaining well-grown stock for ornamental planting in conspicuous places, the Board purchased about 120 000 three-year-old transplants and put them in a nursery where they were cultivated for three years. At the end of that time, they were six years old, and were from three to five feet high, depending on the varieties, and their complete cost amounted to $60.52 a thousand. The same sized stock in a commercial nursery would cost from $125 to $300 per thousand at the nursery. Last spring 26 000 of these trees were lifted and planted out in permanent locations, at a cost of $73.91 per thousand for all labor, superintendence, and transportation over an average haul of two and one-half miles. Therefore the trees in their permanent position cost 13½ cents apiece.

Mr. Clapp. My paper was not prepared in any sense in the nature of a discussion of Mr. Culyer's paper, and I hope you will bear with me if in any connection I have contradicted any of the statements made by him. Mr. Culyer speaks of the very lavish hand with which the work of the Board of Water Supply was carried on, and the expense, but I think when you stop to think

of it, that a great deal of our planting has been at a profit to the contractor, at a price somewhat less than $26 to an acre, — resulting in the planting of 1 250 trees to an acre, which are guaranteed to grow. I do not think you will consider that very lavish.

Mr. E. R. B. Allardice* (*by letter*). About twenty years ago, during the early development of the plans for building on the South Branch of the Nashua River, at Clinton, Mass., what is now known as the Wachusett Reservoir, in which to store water for the supply of Greater Boston, the Metropolitan Water and Sewerage Board, largely through the efforts of its present chairman, Dr. Henry P. Walcott, appreciated the fact that, unless systematically and scientifically studied and developed, the marginal lands of this great inland lake would become waste and valueless, a detriment to the purity of the water supply and a menace to the life of the soil. The watershed area tributary to this reservoir covers about 118 square miles, of which about 7 square miles bordering on the immediate shore of the reservoir and extending along the principal tributary streams are owned by the Commonwealth and are controlled by this Board. This area has been developed along the lines of modern forestry from a pre-arranged plan outlined by Prof. J. G. Jack, of the Harvard Agricultural School, who made a study of the existing condition of the various kinds or classes of land, and outlined a general scheme to be followed, whereby the most economical use could be made of the land, and at the same time preserve and increase the purity of the water supply, protect the land against damaging floods, increase the duration of heavy yields, and preserve the usefulness of the soil.

In entering upon this work, the promoters did not have the advantage of others' experience. Although forestry, as forestry alone, had been practiced successfully for years, it remained for this project to make of it an important branch of the modern large water supply. Therefore, the first question to be decided was: How can this large area of land be reforested, to secure the most satisfactory results, without affecting, to the slightest degree, the paramount purpose of securing a pure water supply?

The problem presented an area made up of arable lots, pastures, timber stands, and sparsely grown sprout lands, which offered a

* Superintendent of Wachusett Department, Metropolitan Water Works, Boston.

splendid opportunity for the practice of modern forestry. The more hardy sprout lands and timber forests could, by the expenditure of comparatively small amounts, be made paying property by making improvement thinnings in them.

As the result of his investigation, Professor Jack recommended that the entire unforested portion of the reservation be planted with native white pines, making a self-perpetuating forest, which would ultimately provide a complete ground cover, requiring no artificial fertilizing or disturbing of the soil, and which would protect the waters of the basin from the direct contamination of manurial matters and soil washed from adjacent farms during heavy freshets or spring floods. The white pine was selected because of its almost universal adaptability to the various kinds of land and growth to be treated, its freedom from leaves, its rising value in the lumber market, and the ease, low cost, and comparative certainty of raising to maturity.

The general policy adopted comprised the raising of seedlings in nurseries established for the purpose; planting all the arable pasture, and light sprout land; underplanting and interplanting the thick sprout and young thinly grown timber land, and making improvement thinnings later as the growth demanded; improving the original timber stands; protecting the entire reservation with a 40-ft. marginal fire guard, internal 15-ft. access roads and a 50-ft. clearing along the shore line of the reservoir. During the first few years of this development, the plantings comprised white pines planted 10 ft. by 10 ft. apart, using oaks, chestnuts, and maples as fillers, making the final stand with trees 5 ft. by 5 ft. apart. This type of planting was used in arable, open pasture, and light sprout land.

There is a truism which says, "Progress is born of experience," and this has been proven to us in our experience with the hard-wood fillers. While the success with the white pines has been extremely gratifying, the failure of the hard-wood fillers to make even a creditable showing has been correspondingly discouraging. Consequently, after the first few years, the composition of the plantings in arable, open pasture and light sprout land was changed to a solid stand, with trees 6 ft. by 6 ft. apart. With this close spacing it is expected, and, in fact, is evidenced at this time, that the

limbs will interfere with each other and accomplish the same clearing of the trunks as was expected of the hard-wood fillers. In the thick sprout and young, thinly grown, timber land the pine seedlings were used to underplant the sprouts and interplant the open areas of the timber land. When planted in this kind of land the pines grow up in a rather delicate condition, until their tops encounter the low-lying limbs of the surrounding growth. At this stage it is necessary to give them assistance if they are to survive. This we have found can be done for about eight dollars per acre, the method being to cut out all growth which is in any way, at this time or within the next few years, liable to stunt or kill the trees. Our experience has shown that in stands of this type it becomes necessary to make a second clearing after a lapse of about ten years. Undoubtedly this is the last help the pines will require until they are about thirty years of age, when an improvement thinning will in all probability be made. In doing this work, due care is taken to preserve all valuable specimens of trees and to leave sufficient fillers of any nature whatever which will act as crowders to the pines.

Of the 4 667 acres, or approximately 7 square miles, of marginal lands, 1 313 acres have been planted to white pine and 852 acres of this area have been thinned once; while a very small per cent. has required a second thinning. In about 300 acres of the natural timber land, improvement thinnings have been made where the receipts from cord wood, ties, and fence posts have about covered the expense. There remains some 600 acres yet to be planted to white and red pine and spruce, which are being raised in our own nurseries.

During the early years of the work all trees were raised in nurseries of our own, while for a few years back several hundred thousand one-year seedlings have been furnished us gratis from the Department of State Forestry. These trees were set out in our nurseries in transplant rows, where they remained two years before they were planted in the field. No distinction has been made between spring and fall plantings, and both have been equally successful.

The following examples show the cost of planting and thinning under widely differing conditions:

(Minimum wage rate, $2.50 per 8-hr. day.)

29.6 acres of very rough scrub, sprout, and weed grass, preliminary clearing, March, 1908	$41.00
Planted in the fall of 1908 with 29 300 three-year-old white-pine seedlings, placed 6 ft. by 6 ft., these seedlings being one year in the seed beds and two years in the transplant beds.	
Raising stock in nursery	205.00
Planting in field	330.00
First protective clearing, December, 1911	330.00
Second protective clearing, March, 1915	304.00
Total	$1 210.00
Received from cord wood in 1911	20.00
Net cost	$1 190.00

Cost per acre to date, $40.00.
Estimated number of trees, 900 per acre.
Cost per tree to date, 4 cents plus.

20.3 acres of old pasture and run-out grass land, preliminary clearing	None
Planted in the spring of 1903 with 9 480 three-year-old white pine seedlings placed 10 ft. by 10 ft., these seedlings were one year in seed beds and two years in transplant beds.	
Raising stock in nursery	$67.00
Planting in field	193.00
Protective clearing, December, 1908	66.00
Total	$326.00

Cost per acre to date, $16.00.
Estimated number of trees, 400 per acre (standing).
Cost per tree to date, 4 cents plus.

FIRE PROTECTION.

It is needless to say that the greatest menace to the forests which we have to provide against, and the one which requires eternal vigilance on the part of each and every employee and all having the interests of the forests at heart, are the forest fires. To prevent their spreading to or from abutting property and to provide a line of defense on which to fight them, a fire guard, 40 ft. wide, has been cut around the entire outside limit of the marginal lands of the reservoir. There is also a network of "forest roads," 15 ft.

wide, throughout the reservation, which acts as supplementary fire protection. The brush and weeds are cut from these two protective systems every alternate year.

On holidays and Sundays during the dangerous seasons of the year (early spring and late fall), men armed with fire extinguishers patrol the reservation to further protect it from the ravages of forest fires. Of late years a motor drawn and operated power-sprayer truck with a capacity of 400 gal. has been added to the equipment and has done very efficient service both in extinguishing fires on our property and in stopping them at the fire guard when approaching from abutting property. Too much emphasis and praise cannot be given to the forest lookout, stationed as he generally is on top of some lonely mountain or hill, for the very efficient and invaluable service he renders in locating fires and summoning assistance.

In the years 1911 and 1912, four forest fires destroyed the pines on an aggregate of about 125 acres. These trees were from eight to twelve years old, and it is needless to say were among the finest stands on the reservation. The cause of these fires were traced to a cigarette butt thrown from a passing electric car, the presence of berry pickers (smoking) on the reservation, and from sparks from a locomotive. From the latter cause we have very frequent fires, and while we experience no difficulty in reaching a satisfactory financial settlement for damages, yet it does seem that some action should be taken whereby the present laws relative to protective devices on locomotives be enforced.

Of late years the forestry plans have been extended to cover the large holdings surrounding the Sudbury storage reservoir and the numerous small distributing and compensating reservoirs scattered throughout the Metropolitan district.

The writer having had no part in formulating the plans for the work herein described, nor in the working out of the plans in their early stages when the success or failure of the venture was in the making, feels that he can, without undue boastfulness, emphasize the success of the work as a whole and the favorable comments heard by visitors from all over the world, and especially by the forestry experts from the United States Government. There are stands of pine now about fifteen years old, on the old spacing of

FIG. 1.

WACHUSETT RESERVOIR EIGHT-YEAR-OLD WHITE PINES PLANTED IN SPRING OF 1903 ON TEN BY TEN FOOT SPACING.

FIG. 2.

WACHUSETT RESERVOIR. TWELVE-YEAR-OLD WHITE PINES.

10 ft. by 10 ft. and about eleven years old on the new spacing of 6 ft. by 6 ft., where there are living to-day 95 per cent. of the trees set out, and which have grown so as to provide a complete cover, and which will require the first improvement thinning within a year or so. It is a common sight to find trees which have grown from 2 to 3 ft. a year with a 6-in. butt, and it certainly is very pleasing and gratifying to be told by men who make a study of this subject and travel all over the world in so doing that nowhere in the United States is there such a fine showing. Certainly the Commonwealth of Massachusetts is to be congratulated upon being, through the Metropolitan Water and Sewerage Board, the pioneer in making so important a subject an adjunct to the large municipal water-supply systems of to-day, and to have set the example which other states in the Union have seen fit to emulate in this same connection.

DOUBLE SAND FILTRATION OF WATER AT SOUTH NORWALK, CONN. — REMOVAL OF ORGANISMS, TASTES, AND ODORS.

BY HARRY W. CLARK, CHEMIST MASSACHUSETTS STATE DEPARTMENT OF HEALTH.

[*Read September 7, 1915.*]

South Norwalk is a city of about 10 500 people, situated on Long Island Sound, forty-two miles from New York. A public water supply was introduced in 1876, and this supply has been enlarged from time to time by the acquirement of various new sources and the construction of new reservoirs. The total population supplied is about 13 000, other communities than South Norwalk receiving this water. The water system includes ten square miles of watershed, 500 acres of land, and four reservoirs with a capacity of 700 000 000 gal. The two principal reservoirs are City Lake Reservoir and Rock Lake Reservoir. The consumption of water is large for the population supplied, averaging about 2 500 000 gal. daily, or about 200 gal. per capita. Few meters are installed.

The water of the South Norwalk reservoirs has through many years been subject at times to enormous growths of taste- and odor-producing and other microscopic organisms. Asterionella, Anabæna, Dinobryon, Aphanizomenon, etc., flourish very vigorously at certain periods, sometimes singly and sometimes together. These growths are generally greatest in the months of August, September, and October, but occur at other times also. Growths of certain of these organisms are prominent as a scum at times on the surface of considerable areas of the main reservoirs. Samples of water shipped to me in the summer season from City Lake Reservoir have occasionally been long enough in transit for the disintegration of these microscopic growths to have occurred and to give the water the intense, vile, pigpen odor caused by this disintegration and decay. Cities are slow to act, and a long-suffering public put up with the tastes, odors, and generally dis-

agreeable conditions of the water supply through many years. Improvement was earnestly desired by the water commissioners and the citizens. Various mayors recommended action in different inaugural addresses, and in January, 1905, Mayor Dow, speaking of the filtration works then under construction, stated: "We who have suffered from the water conditions as they have prevailed can appreciate fully what filtration will mean.' Previous to this, in March, 1904, the speaker was retained by the South Norwalk Water Commissioners, Messrs. Stephen Hatch, Christian Swartz, and Franklin Smith, working in coöperation with a special water committee, to advise in regard to improvement of the water and filtration. The water question was studied and double sand filtration recommended. Some experience with this water several years earlier than 1904 and the results of filtration investigations upon the water of Ludlow Reservoir, Springfield, Mass., were the foundation of the advice given.

At Ludlow Reservoir, the old water supply of Springfield, filtration investigations for the Massachusetts State Board of Health and the Springfield Water Board, carried on largely under the direction of the writer during the year 1901, had shown that water from a shallow reservoir containing at times enormous growths of Anabæna and other taste- and odor-producing organisms, together with much organic matter, iron, and color, could be rendered entirely satisfactory and free from tastes and odors by aëration and double sand filtration.

At Springfield, the primary experimental filters were operated at a rate of 2 500 000 gal. per acre daily and the secondary filter at a rate of approximately 10 000 000 gal. per acre daily. This experimental plant removed not only the organisms and the tastes and odors, but caused a very substantial reduction of the iron, organic matter, and color of the water so treated. In fact, during the four months of the year when the applied water was highest in color, the filter removed 63 per cent. of this coloring matter. With the results of this Springfield investigation as a precedent, the writer had little hesitation in recommending a double sand filtration plant for South Norwalk, and the results of nearly seven years' operation of the filters have been an ample vindication of the advice then given.

Briefly, the plan of filtration was to aërate the water thoroughly, then pass it through a filter containing about three and one-half feet in depth of coarse sand, then aëration and a second filtration during that portion of the year when the water was in its worst condition. Rates similar to those successful at Ludlow were planned for; namely, 2 500 000 gal. per acre daily for the primary filter and 10 000 000 gal. for the secondary filter. The object of this filtration was, let me make it clear, not the improvement of the water bacterially, although, of course, this followed, but the change of a water at times almost entirely unsuitable for domestic consumption, owing to its disagreeable qualities, to one entirely satisfactory in every respect. Just how bad the water in the city was at times before the filters were installed, I have little personal knowledge. I understand, however, that for considerable periods of each year the taste and odors were decidedly rank and the turbidity of the water very noticeable. On several occasions when visiting the filters in the summer season since their construction, the water over the primary filter has, owing to the organisms present, looked like a thick green pea soup. It is a fact, moreover, that the water board of a certain Massachusetts city visiting South Norwalk on a tour of inspection became decidedly opposed to filtration on account of the strong odor at that time around this South Norwalk filtration plant. They could hardly be persuaded to look at the improved water after filtration, apparently deciding that a filtration plant would be a nuisance. William S. Johnson, C.E., of Boston, was associated with the writer in preparing the designs of the filters, and to him much of the success of the work is due. Samuel W. Hoyt, C.E., of South Norwalk, was in direct charge of construction, and the Bunting Construction Company were the builders.

The filters are located about 1 000 ft. south of the city's largest reservoir, known as City Lake, and water flows from the lake to the filter through an 18-in. pipe. City Lake is about 260 ft. above the city level, which is practically sea-level. The filters were built during 1906 and 1907 and were put into operation on June 22, 1908. They are of concrete construction and covered. The primary filter is divided into three sections, each 78.4 ft. wide and 145 ft. long inside measurement, slightly more than 0.25

acres; the floor is 15 in. thick under the piers and 6 in. midway between. There are fifty piers in each section, 28 in. square at the base and 20 at the top. The concrete roof is of groined-arch construction, 6 in. thick at the summit of the arch. It is not reinforced. Each span is 11 ft. 8 in., and the arch is half an ellipse with a rise of 2 ft. 6 in. There are thirty manholes in each section. Near the center of the floor of each section an effluent channel is placed, 2 ft. 10 in. wide and 8 in. high, covered with reinforced concrete slabs. From this main channel, lateral lines of 10-in. split vitrified pipe are laid in the invert of each vertical curve across the filter beds. The underdrains are covered with 14 in. of graded gravel. The sand in each filter is 3 ft. 9 in. deep and of an effective size of from 0.35 to 0.38 of a millimeter.

No sand could be discovered within about seven miles of the filter and the railroad was many miles away. There was, however, a gravel deposit just a mile distant across country, and we finally, after extended investigations, decided to use the sand contained in that gravel. To obtain one yard of sand it was necessary to handle something more than three yards of material, and the screening was all done by hand, as the circumstances were such that it did not seem to be economical to put in a mechanical screen. Then a new road, a mile in length, was built across country and the sand was hauled to the site of the filter. After reaching the filter it had to be washed to remove the fine material and dirt, taking out about 5 per cent. in the process. The cost of the sand placed in the filter was about $2.45 per yard.

The washing at this place was of necessity done inside of the filter, as the wash-water was obtained by gravity from a reservoir, and the head was not sufficient to deliver any considerable quantity of water above the roof of the filter. At first we thought the location of the washing apparatus inside of the filter was going to be a disadvantage, but it proved to be the opposite.

The sand was dumped through one of the manholes into a hopper which fed directly into the washer, and the dirty water was carried off through one of the drains. The clean sand was discharged into wheelbarrows on a plank run, and a constant stream of wheelbarrows passed the outlet of the washer.

The water comes to the primary filter through an 18-in. pipe

and passes to the aërator placed in a concrete aërating chamber. The aërator is a steel box 9 ft. 3 in. long, 6 ft. 6 in. wide, and 4 ft. high. It has 6 836 holes $\frac{3}{16}$ in. in diameter spaced 1 in. between centers. This form of aërator was adopted after various experiments made by me at the Lawrence Experiment Station in regard to the quickest and most thorough method of introducing air into water free from air; that is, water that, owing to the presence of much organic matter in a state of change, had exhausted the free oxygen normally present. It was found by these experiments that even weak sewage devoid of oxygen could be nearly saturated with air when dropping from a box of this description through $3\frac{1}{2}$ ft. of air. The small streams coming from these $\frac{3}{16}$-in. openings, twist and break and the water becomes a white-foaming mass, about 6 in. below the aërator pan. The aërator is regulated by a float valve.

The water after passing through the primary filter collects in a central effluent channel and flows to four 14-in. Venturi meters, one for each section of the primary filter and for the secondary filter. These meters register and record the rate of filtration, the elevation of water in each bed, and the loss of head. From these meters the water passes to a central chamber under the operating house, and from there it may be passed to a secondary filter or to the city mains or to a clear water reservoir with a capacity of 250 000 gal. The secondary filter is of the same design, construction, and dimensions as each section of the primary filter.

In the operation of the experimental filter at Ludlow one phenomenon was noticed that occurs often with the primary filter at South Norwalk; that is, during the period of each year when the organic matter or organisms are in the greatest abundance in the reservoir water, the quick oxidation of this organic matter in the sand filter causes a complete exhaustion of the oxygen, and the remaining unoxidized organic matter then takes oxygen from the iron and manganese oxides in the sand, iron and some manganese hence coming through in solution. While this adds to the load of the secondary filter, this iron and manganese is thoroughly oxidized by aëration before reaching the surface of the secondary filter and hence acts as a precipitant, and the secondary filter removes more organic and coloring matter at such times than

during other periods of the year. The question may be asked whether this action could not be avoided by passing the water more rapidly through the primary filter and thus not giving time for oxygen exhaustion. This might be done except for the load of organisms occurring at these periods. Attempts were made at Ludlow to overcome this trouble by the operation of a filter with a shallow depth of sand, and while this was more or less successful, it did not entirely obviate the difficulty.

At the Ludlow experimental filters the primary filter caused a very satisfactory removal of tastes and odors until Anabæna became very abundant in the applied water, the number of organisms of this kind reaching at times nearly eleven thousand per cubic centimeter, and at such periods the effluent from the primary filter had decided tastes and odors, these tastes and odors being, however, entirely removed by the secondary filter operating at a 10 000 000 rate, and this is very largely the experience at South Norwalk.

Owing to the level of the filter being nearly that of the reservoir from which water is taken, the lack of water pressure for the operation of the customary sand-washing machines has caused some difficulty in washing the sand economically. Generally, sand washing is carried on as follows, the sand being washed in place. Water enters at special inlets at the filter's surface and it flows over the sand controlled in fairly narrow channels by wooden baffles placed in the sand. The sand is disturbed by rakes, and the accumulated material, dirt, etc., is washed across the bed to specially designed waste drains.

The filter throughout the seven years of its operation to date has been entirely satisfactory and successful in accomplishing the object for which it was constructed. Organisms, tastes, and odors are completely removed, together with at least 50 per cent. of the coloring matter of the water, the apparent color removal being much greater than this. According to South Norwalk physicians, it has also had a beneficial effect upon the health of the community, but I have no statistics upon this point. The cost of this plant with a total filtering area of one and one-fourth acres was just about $100 000. The statistics for the year ending May 1, 1915, are as follows:

SOUTH NORWALK WATER WORKS, JUNE 15, 1915.

Yearly Report at Purification Plant for the Year ending May 1, 1915.

Total number of gallons of water used	923 256 331
Daily average for year was	2 529 469
Greatest amount filtered on one bed between cleanings	37 095 370
Least amount filtered on one bed between cleanings	2 508 545
Greatest amount filtered on one bed per acre	148 381 480
Least amount filtered on one bed per acre	10 034 180
Total operating cost without supplies	$4 335.20
Operating cost per 1 000 000 gal. filtered	$5.23
Average amount filtered per cleaning, gallons	11 398 229
Number of times secondary filter was cleaned	9
Longest run on secondary filter	93 days
Shortest run on secondary filter	9 days
Greatest amount used in 24 hours (Dec. 29, 1914)	3 125 485
Least amount used in 24 hours (Oct. 25, 1914)	2 087 615
Average rate of filtration of primary filter, gallons	3 300 000
Average rate of filtration of secondary filter, gallons	10 000 000

DISCUSSION.

MR. JAMES S. DUNWOODY.* I would like to ask Mr. Clark if he has any temperature data, especially for the summer months? I understood him to say that this Asterionella lasted throughout the entire summer.

MR. CLARK. I never noted the temperature the water reaches at the time when these organisms begin to be prominent at South Norwalk. The reservoir there is quite shallow and I have no doubt the temperature gets very high. They may have some data there. I may say that I have had very little to do with this filter plant during the six or seven years since its construction. They have been able to run it satisfactorily themselves, and it has not been necessary to call me in but once or twice to help a little.

MR. DUNWOODY. Do I take it this lake is formed by springs?

MR. CLARK. No, I should say not. It comes from brooks quite largely.

MR. DUNWOODY. With what experience I have had with this algae, it never lasts a full season to much extent unless the temperature of the water is kept quite low.

* Erie, Pa.

MR. CLARK. I have had quite a different experience. I have seen algae last through many weeks of high temperature. The reservoir at Ludlow, which is a shallow reservoir with stumps of trees sticking up through the water, has high numbers of organisms through the warm months of August and September. Whether it appears at one temperature or another depends altogether on the kind of organism.

MR. DUNWOODY. In our water supply at Erie we are troubled considerably with the Asterionella. Our temperature in the winter time gets very close to freezing, 33 to 35 degrees, and in the summer as high as from 70 to 75 degrees, but it is at what you might call the period of the lake turnover that we are most seriously affected by the growth.

This last year was the worst season we have ever had. The period lasted nearly two months, from May first to July first, but when the temperature of the water reached above 55 degrees we had a very sudden, practically complete, disappearance of the Asterionella.

MR. CLARK. At the present time [September] the temperature of the water at South Norwalk is, I suppose, as high as it gets during the year. I don't know what its temperature is, but the City Lake Reservoir is now a nice green color through growths of Aphanizomenon, — not odor-producing except by decay, but it is very thick in the water at the present time, and of course clogs the filters as much as any organism.

MR. ALLEN HAZEN.* I think the author deserves our commendation for his part in producing one of the most complete plants for removing tastes and odors that has ever been built. And it is also well that this paper has been presented now because it calls attention to a very important problem in treating waters to improve their physical properties, by removing tastes and odors. That is one of the things that I have had the pleasure of talking to the Association about from time to time in years gone by until you must be tired of hearing about it. But it is something I believe in very thoroughly. Treating water for disease-producing properties is all well enough, but it is very important to remove these objectionable qualities, and none of these are more bother-

* Civil Engineer, New York, N. Y.

some than tastes and odors, and it is very well worth while to spend the necessary money, which, after all, is a comparatively small amount, and clean up the water until the tastes and odors disappear, and to make it just as attractive in every way as spring water. This is something that has been done in a few cases and it needs to be done, and I feel sure is going to be done, in a great many others.

MR. S. S. HATCH.* I am nothing of a chemist; I know nothing of chemistry. But we have a very efficient man at the filter, and I can say to you that the filter not only takes away the odor and the taste, but all our doctors in South Norwalk tell me that their incomes have been reduced at least $20 000 per annum and that they have nearly forgotten how to take care of bowel complaints, they have so few of them in South Norwalk. One of the druggists said that the call for bowel medicines had stopped on account of this filter. Of course we have no fear at all of typhoid.

We are very careful in the management of the filter. The original cost of it was about $100 000; the houses that the men live in and other improvements added $20 000 to the cost of the plant. The interest and the expense all told is about $10 500 a year; less than 90 cents per capita per year. We did not make any change in the rate for water on account of it. We have a small net income from the plant.

MR. DANIEL D. JACKSON.† The percentage of wash water to wash the filters is what?

MR. HATCH. At the present time we are raking the sand and are using raw water; as we have plenty, we do not measure the amount. It comes in by gravity and is kept about 4 in. deep. The men rake the sand, the scum rises and flows off in a quick current. We use a dashboard. Perhaps the opening will be, between two columns, 12 ft. It makes a very quick current and goes out into a drain. In the spring the sand that has been taken out (about 1 500 yd.) is washed in a washing machine and replaced. We stop raking in October. We have a little box, about 10 ft. square, high enough to give us pressure, and that water is cleaned through the sand in that box. The water in the reservoir

* Water Commissioner, South Norwalk, Conn.
† Of Columbia University, New York.

at that time is in pretty fair condition. It is in March, right after the ice gets out of the sand, that we wash and return it. I think we take about 200 000 gal. of water per section for washing, by raking, but it is not filtered water. The machines use about 100 gal. per cubic yard of sand.

MR. L. M. HASTINGS.* I would like to ask about cleaning the sand in the filter. Have you any idea, Mr. Clark, how much water it takes for washing the sand? Either in gallons or per cent. of water filtered?

MR. CLARK. The sand is washed as follows: Water flows into each section and is flushed across the surface of the sand while the sand is being stirred by rakes in the hands of workmen, and then goes out through a drain on the other side of the filter, carrying the dirt with it. There are baffles placed across the sand so as to make a fairly strong current of water over the section of the filter being washed.

The frequency of washing depends altogether on the quality of the water going through. I think that the shortest run was something like eleven days in 1915. The longest was perhaps five or six times that amount.

The water is really of no value that they use in cleaning. It is the reservoir water, and they always have enough. They don't use filtered water. We do not know how much water is used for washing.

MR. ALLEN HAZEN. I can answer some of the questions from our experience in operating several plants. They have been running for the last few years, and the water used for washing the sand usually runs from one fourth to one half of one per cent.

MR. J. M. DIVEN.† In the southern states algae troubles last for much longer periods than in the cooler climate of the North, as the cold weather either kills them or causes them to seek shelter in deep water, where they do not cause much trouble, just spend the winter multiplying and preparing to give trouble when the warm weather comes. At Charleston, S. C., where the supply is an impounded surface water, they were active for nine or ten months

* City Engineer, Cambridge, Mass.
† Superintendent of Water Works, Troy, N. Y.

each year, some years failing to take any vacation, keeping on the job the entire year.

In one case, in a northern city, the trouble came so suddenly and the water got so bad that it was impossible to operate the mechanical filters, as they clogged up faster than they could be cleaned, and the filter tubs, rakes, etc., became plastered with a sticky and stinking mass. The men who attempted to operate the mechanical rakes to keep the filter beds opened were nauseated and unable to attend to the work for more than a few minutes at a time. Asterionella and Anabæna were the principal offenders in this case.

Mr. Jackson. My question regarding the wash water had reference to some experience which we had in the Department of Water Supply in filtering water containing large amounts of algae. We had on one of our filters a very large growth of algae, and we tried the treatment with copper sulphate. The amount of wash water which we were using at times for the plain filtration of that water ran as high as 25 per cent., a practically impossible amount to use. It often ran as high as 8 and 10 per cent., due to the thick growths which occurred in the pond from which we were filtering the water. Now, it would be perfectly feasible to filter a small amount of water, water containing a small amount of algae, either by sand filtration or by mechanical filtration. But when it comes to very heavy growths, operation under very bad circumstances may completely stop. So we were obliged to use copper sulphate in connection with filtration. And on one occasion, when the wash water ran as high as 25 per cent., we added copper sulphate to the pond, and in the course of a few days the wash water dropped down to about 3 per cent., which was the normal amount. The point which I wanted to make was that on many waters it would be impossible to treat by filtration, either by slow sand or mechanical, without also the accessory use of copper sulphate. I would like to ask Mr. Clark if copper sulphate was necessitated at South Norwalk at any time.

Mr. Hatch. The experiment with copper sulphate was made at two different times in one year, — in the early season and about October. We found our filter clogging in about six days, the algae growth was so heavy. We tried it once and we had a very ludi-

crous effect. It killed a few fish in the pond, and people thought that everything was polluted. They called it a cesspool, and at one of the factories said they found the copper in their chemical solution. Mr. Newland, state chemist, could find no trace. So we never tried it again, but when we did use it the filter ran twenty days instead of six without cleaning. But now we spend the money in labor instead of using the copper.

MR. DIVEN. Mr. Clark, what was the number of algae in the water?

MR. CLARK. I don't know. I have had several samples that ran up to thirteen or fourteen thousand to the cubic centimeter. I think this organism found the other day was five or six thousand per cubic centimeter, — very thick, very green. It looked like a green pea soup.

MR. DIVEN. The speaker agrees with Mr. Jackson that water may be so heavily impregnated with algae that it would be impossible to treat it by that process, as the filters would clog up faster than they could be raked, even if men could enter and remain in the chambers to operate the rakes. The stench from some forms of algae would make this almost impossible.

MR. CLARK. I have had experience only with reservoirs at Ludlow and South Norwalk. Sand filtration seemed to go all right at these places.

MR. DUNWOODY. That was the experience we had with the Asterionella. The beds were not running more than two hours before there was a complete plugging up, and a wash was required. With a wash every two hours our wash water got up as high as eight per cent. We were right on the verge of using copper sulphate. We did not want to use it unless it became a necessity, and if the growth had gotten any worse we would have had to do it, but the conditions gradually got better from that time on because of the increase in temperature.

MR. HAZEN. It may be well to put on record that at the Ludlow reservoir, to which Mr. Clark has referred, the water, which is certainly as rich in algae as in almost any reservoir there is, was filtered successfully in the summer for quite a number of years through sand filters, and in that case no wash water or copper sulphate was used at all. The surface of the sand was raked and

sometimes strained, and it never received any other treatment. The filters are uncovered.

MR. WILLIAM WHEELER* (*with addition by letter*). In Winchester, Ky., the water was taken from an impounding reservoir built in 1890 on a creek in the fertile Bluegrass region of Kentucky where the underlying formation is of limestone. The reservoir, originally of only some thirty million gallons capacity, was increased, in 1894 and 1903, to about eighty-five million gallons. It has a watershed of about twelve square miles, from which the creek flow varies from torrential volumes following heavy cloud-bursts to scarcely measurable quantities at times in the driest seasons.

Odor and taste in the water first appeared appreciably during the hot summer months two or three years after the works were built, and continued in variable but usually increasing degrees thereafter. The installation in 1893 or 1894 of mechanical filters of the pressure type, supplemented by aëration, mitigated quite effectively the objectionable conditions in the water supplied, until 1901, when the odor of decaying organisms and their secretions became extremely offensive, — substantially all public water supplies in that region experiencing the same trouble. Better seasonal conditions in 1902, aided by further provision for aëration and for taking water where least infected with the offending organisms, made the service of that summer fairly acceptable.

A sample of the raw water collected early in September, 1901, and examined two weeks later at Boston by Horatio N. Parker, was found by him to contain very large quantities of Clathrocystis and Oscillaria, with much smaller numbers of Crenothrix and of various protozoa, and with minimum numbers only of Anabæna. Doubtless great changes in relative numbers of the different algal forms contained in this sample had occurred between the time of its collection and that of its examination, especially as it had been forwarded without icing or other thermal protection.

Conditions were somewhat less acute in 1902, and the effects of the algae yielded fairly well to aëration and filtration.

Early in 1903, on learning of the successful use in the South, of copper to rid watercress beds of Spirogyra, we secured the coöperation of the United States Department of Agriculture in making

* Consulting Engineer, Boston, Mass.

what appears to have been the first application of copper sulphate to prevent algal growths and to neutralize their effects in a reservoir for public water supply.

Algae first appeared that year in sufficient numbers to cause objectionable odor and taste on or about the first of July, and microscopical examinations made during the ensuing weeks — before applying the treatment — showed averages per cubic centimeter of, — Anabæna, 7 400; Clathrocystis, 1 100; and Eudorina, 200. The treatment was applied July 9, by placing copper sulphate in a coarse sack which, suspended from a rowboat, was drawn to and fro over the surface of the reservoir, giving especial attention to those parts which seemed to contain the largest number of organisms. There were then about 25 000 000 gal. of water in the reservoir, to which about 50 lb. of copper sulphate were applied, or at the rate of one part to 4 000 000.

Counts from surface samples showed the quick effect of the treatment upon the number of filaments of Anabæna Flosaquae thus:

	Filaments per c.c.
July 6 (before treatment)	3 400
July 10 (after treatment)	54
July 11 (after treatment)	8
July 13, 15, and 20	0

Meanwhile the original closed or pressure filters had just been replaced by a new and larger installation of mechanical filters of the gravity type, with simple appliances for some incidental aëration of the water as it was discharged from the coagulation basin into the filters.

After treatment the water in the reservoir soon cleared, and as filtered and supplied to consumers was substantially free from odor during the remainder of the season. The following year, 1904, one application only of copper sulphate was given, as that sufficed to prevent a recurrence of the algal growths during the season. In that year, a second reservoir of about 105 000 000 gal. capacity was built on a fork draining about half of the same watershed. This reservoir has been less affected by algae, and has been treated less frequently than reservoir No. 1.

The records of the copper sulphate treatment from 1904 to 1909, inclusive, are incomplete, but it has been the practice to treat reservoir No. 1 each year on the first appearance of algae in significant numbers. During the last six years, 1910 to 1915, the first application has ranged from May 27 in 1911 to August 8 in 1910. The average time of first applications each year has been about June 18; and of the latest ones each year, when applied more than once, about September 2.

The number of applications in each year, — 1910 to 1915, inclusive, — most of which were dry years, — has ranged from one in 1913 to four in 1911 (rainfall in May, June, and July was 2.63 in., and in August 2.51 in.), with a total of sixteen in the six years. Four of these dosings were substantially lost or neutralized by rainfall and stream flows that immediately followed their application. The average dose was at the rate of one part to 3 000 000 of stored water. Under like meteorological conditions, there appears to have been very little, if any, progressive change in the amount of copper sulphate required from year to year.

The reservoirs have from the beginning been stocked with fish by a local fish and game club; and the superintendent reports that injurious "effect of the treatment on the fish has been noticed but once since the treatment was begun, which was in 1911, when some few were killed. These were of the new light or crappie species, and I attribute their destruction to the heavy dosing made along the edges. . . . The water is stocked with St. Mary bass, new lights or crappies, brim, and catfish, which have come in from the creeks. Each year the catfish die in large numbers at the spawning season in early May, but this occurred before the copper sulphate was applied."

REASONS FOR ADOPTING THE SOLID-WEDGE TYPE OF VALVE IN THE BOSTON WATER DEPARTMENT.

BY GEORGE H. FINNERAN, SUPERINTENDENT DISTRIBUTION BRANCH WATER DEPARTMENT, BOSTON, MASS.

[*Read September 8, 1915.*]

It is not my purpose, in this short paper, to enter into a detailed or technical discussion of the merits or demerits of either the solid-wedge or double-disk type of valve. Nor do I intend to particularize as to the various makes. That would be a very large task, because of the many kinds and great variety of mechanism. Furthermore, it would tend towards the identification of the valves, and that of course is not within the scope of this organization. I shall simply make a few general statements which I trust will show the principles that influenced the officials of the Boston Water Department in deciding to continue the manufacture and use of the solid-wedge type of valve.

A valve, as generally considered by water-works men, consists in the main of three parts, the casing or body, the stem, and the gate or plug. There appears to be a general uniformity or standard in the design of the casing and stem, but in the matter of plug or gate, for some reason or other, a number of the manufacturers have abandoned the old solid-wedge type of plug and have taken up with many and varied kinds of loose double disks with more or less complex expansion devices.

Some of the manufacturers produce more than one design of actuating mechanism. This fact might possibly indicate that there was doubt as to which design was the most efficient.

Whether or not the departure from the old solid wedge was the result of a demand on the part of the consumer for something different would be interesting to know.

While it might be inferred by the title of this paper that the adoption of the solid-wedge type of valve by the Boston Water

Department was of recent occurrence, as a matter of fact that type of valve has been in use since the present system of piping was laid in 1848, a period of sixty-seven years.

The Boston Water Department manufactures its own gates, hydrants, bronze fittings, etc. All its fixtures are made from its own special designs, and while in a general way they are similar to those used by various water works throughout the country, yet in detail they differ.

Recently, new sets of designs and patterns have been prepared for the manufacture of valves from 4 in. to 12 in. in diameter. The question of changing from the solid wedge to the loose double disk was considered, with the result that we adhered to the solid wedge with some slight modifications in its structure for the ultimate purpose of reducing its cost.

We were influenced towards this decision by several reasons, principal among which are the following:

Sixty-seven years of experience with the solid wedge has developed no convincing reason why we should discontinue its use.

No inherent weakness or objectionable characteristics have been observed during that time.

It has done its work satisfactorily. Whenever it becomes necessary to remove from service a gate with a plug of this type, it is usually because of some defect in a part other than the plug.

This good record of durability and satisfactory service of the solid wedge is nothing more than a demonstration of the proposition that in things mechanical, simplicity should be the preëminent characteristic, and it is only through that property that true excellence is attained.

The solid wedge can certainly lay claim to being mechanically simple, and it is in this quality that we find its greatest virtue.

It is claimed by those favoring the double-disk type of valve in preference to the solid wedge that with the former a double seating is assured when the gate is closed, with consequently increased tightness, and with very little frictional resistance on the way down.

In considering the merits of the respective types, we were impressed by the fact that there is practically but one seat to a valve

in operation, and that is the seat opposite to the side on which the pressure is. Hence the superfluousness of the second disk in the double seating plug of the expansion type.

Consider, for example, a closed 16-in. gate sustaining an unbalanced pressure of 100 lb. to the square inch. Here we have a stress of about 10 tons forcing the valve against its seat. Why not allow this great force to seat the wedge tightly instead of opposing it with a counter force generated by the expansion of the disks, as in the double-disk type of gate? I have serious doubts if under the conditions just described that a double-disk plug seats tightly on both sides. I have fears for the strength of the toggle or expanding device against such a tremendous strain. It may be that a gate of that type realizes its primary purpose more by being forced against one seat by the pressure than by closing against both seats through its own expansion, as it theoretically is supposed to act.

In a hydrant designed and built for the high-pressure fire service of Boston, the nozzles are controlled by bronze valves consisting of a single solid disk, loosely seated but closing tightly when the pressure is admitted to the barrel. Although these valve disks control an orifice only 3 in. in diameter, they prove the efficiency of the solid wedge by seating tightly through the force of an unbalanced pressure.

I am informed that in San Francisco they have advanced so far on the premise that there is but one seat to a valve in action that they are building a valve with parallel seats and a solid plug without a taper, thus depending entirely upon the pressure to seat the valve.

What moved us, furthermore, in this matter was the uncertainty of the double-disk type of valve overcoming rust and other solid matter that is generally encountered between the seats of valves infrequently operated, as against our ability to dislodge with the solid wedge an amount of such matter sufficient to allow of the tight closing of the valve by manipulating the wedge; that is, raising and lowering it and crushing and washing out the obstructing material. The horizontal movement of the expanding disks is more apt to drive the matter against the seats with such force as to adhere and prevent tight closing.

What also impressed us was the liability of the double-disk plug, by reason of its looseness when not seated, to vibrate during a quick rate of flow, water hammer, air pockets, or any other condition that would cause a disturbance in the main. The sound of this vibration might enter houses nearby and prove objectionable, but its serious possibility is the wear on the more or less complicated mechanism of the disks. I know of cases where the rings on the disks have been shaken off by vibration.

One of its weakest spots, in my opinion, is the opportunity for rust or other matter to accumulate between the disks and adhere to the various knuckles, hinges, wedges, trunnions, loose joints, etc., of the operating mechanism, clogging them and interfering with their action. In waters of heavy lime content, or those with a corrosive constituent, the effect would tend practically to put the valve out of commission.

While in theory it is very attractive to contemplate the loose double-disk plug descending without frictional resistance and upon reaching the bottom to expand to a water-tight bearing on both sides, yet it strikes me that such smooth action a great many times is in theory only.

In a large city where a gate is frequently operated and subject to rough usage by unskilled and indifferent men who are inclined to apply a surplus of energy to their work, a plain rugged type of valve is almost a necessity.

After an earnest consideration of the various points for and against both types, we felt that we could not very well improve on the simple, sturdy, and honest solid wedge that descends into its seat, filling the same tightly and performing the chief function of a valve, viz., the absolute stoppage of the flow. Without complex mechanism its very simplicity insured its durability and reliability of action, and its record of many years' service without defect or weakness confirmed its claim for all those good qualities.

The wisdom of changing from a fixture of proved satisfaction to one which possessed possibilities of uncertain performance seemed doubtful to us, hence our decision to continue with the solid wedge.

The object of this paper, however, is to elicit a discussion among the members present with a purpose of setting forth any good or

bad points in connection with both types of valve that have not been mentioned by the writer. I am sure that there are other angles from which this "wedge question" may be observed, and in the minds of those present there are possibly more weighty factors and convincing reasons why one type of valve is superior to the other.

(For discussion of this paper see page 110.)

REASONS FOR USING THE DOUBLE-DISK TYPE OF VALVE.

BY J. M. DIVEN, SUPERINTENDENT WATER WORKS, TROY, NEW YORK.

[*Read September 8, 1915.*]

The writer having had no recent experience with solid-wedge valves, in order to get some knowledge of them as now manufactured, referred to the catalogues of valve makers. Of the many catalogues consulted, three only listed and described solid-wedge valves, and these three manufacturers also made parallel seat valves. The solid-wedge type seemed, therefore, to be in a minority, so far as the manufacturers are concerned. The class of goods put on the market is a good indication of the demand, for manufacturers are always trying to meet the demand, and to manufacture what they can sell. The writer's personal knowledge of water-works practice is that comparatively few solid-wedge valves are used, and, as water-works men everywhere are looking for what is best, it does not seem that solid-wedge valves would have been overlooked or rejected by them if better than, or even equal to, the parallel disk type. The fact that a valve or other appliance has been used for a long term of years and has given satisfaction is not positive proof that something different might not be an improvement.

The writer has used the double, or parallel, disk type of valve because to him it seemed to be of better mechanical construction, to offer less trouble in operation, and less wear. In the operation of double-disk valves there is practically no friction, and such as there is does not come on the water-tight portion, but on the wedge nuts, where wear in no way affects the tightness of the valve.

The solid-wedge valve came to us from England in the early days of water-works construction, when we imported most of our cast-iron pipe from Scotland. But it was not many years before our manufacturers departed from these patterns and devised, first, a modified wedge valve, one with the wedge principle but double disks, forced to their seats by inside wedge action.

About the first of this type was the Peet Valve (Fig. 1), not now manufactured. This was a taper seat valve, of the wedge principle. The valve was fitted with a pear-shaped wedge, the large end downward with an extending spindle which engaged with a projection cast in the body between the seats, so that as the valve closed the spindle came in contact with the projection in the case, and the further travel of the disks caused the wedge to force them to their seats. Some of the double-disk valves in use to-day are developments of this type.

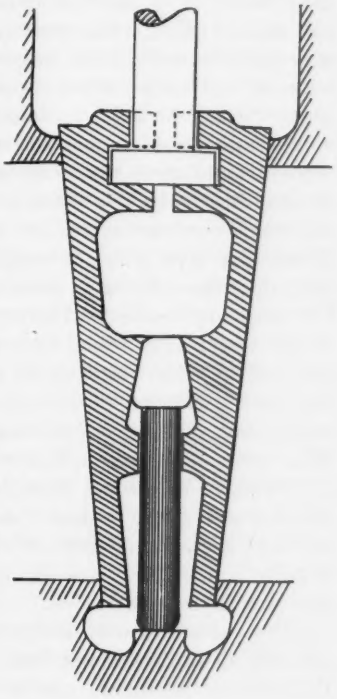


FIG. 1.
PEET VALVE.

In operating a parallel disk valve, the instant the pressure on the disks exerted by the wedge nuts is released, they are perfectly free to rise from their seats; there is absolutely no sliding or rubbing motion between the seat rings and the disk rings, the parts of all valves that make them tight when in good condition, and cause leaks when worn or injured. In closing the valves the disks are free until in their place opposite the seat ring, when the only motion is an outward pressure against the seats, without any sliding or rubbing to cause wear on the gate rings. The only possible grinding or rubbing of seats is when the pressure is all on one side of the valve. A little care in the operation of valves soon relieves this as a very small opening will quickly equalize the pressure; with large size valves this is accomplished by the by-pass, saving wear on the main valve.

Various devices have been contrived by valve manufacturers

for expanding the disks to their seats, each claiming superiority in this particular. But we who use double-disk valves believe that while the disks are free to adjust themselves to their seats there should be as little lost motion as possible between the disks and seats, so that when operated the disks are in practical contact with the seats, thus shearing off any accumulation of rust, sediment, or foreign substance of any kind, and insuring perfect contact when the valve is closed. In all of the better makes of valves both the seats and contact part of the disks are of noncorrodible metal, so that there is no rusting of the contact parts to affect the tightness of the valves. Both types are wedge valves, depending on wedge action for tightness; the wedge action of the double-disk type being accomplished by the wedge nuts, which take all of the rubbing or grinding wear, while in the solid wedge type this wear comes on the gate or disk and seat rings. Wear on the wedge nuts, which are made of hard material, will be less than on the softer metal of the packing rings, and will not affect the water-tightness of the valve. This wear is also easier to repair than that on the packing rings, especially the seat rings. Wear on the seat rings of the solid-wedge type of valve seems to the writer to be sure, in time, to cause leaky valves. Of course the clearance at the bottom of gate chamber allows for wear, permitting the gate to go down until it is tight; but such wear would have to be absolutely uniform and equal on both the wedge and seat to leave a tight valve.

As to the mechanical design of the solid-wedge type; is there not difficulty in machining both bodies and plugs to a standard? Undoubtedly there are special machines for this purpose, and possibly the difficulty has been overcome; but has it been overcome to the extent of making all parts interchangeable? Is it not necessary still to fit each plug to its own body?

Some difficulties in this respect seem to have been encountered, as various devices have been used to obviate them, such as casting the bodies in two sections and, after machining, bolting them together with the plug in place, and using a lead gasket between the flanges. The writer does not know how satisfactory this proved, but can see a possibility of trouble owing to the distortion of the lead gasket. Another device tried was using a solid body and

casting a soft metal seat. But it would seem that the soft seat would have a short usefulness.

After all, is not the wedge-shaped double disk, or even the parallel disk type, a modification of the wedge intended to overcome the difficulties met with and defects found in the solid-wedge type, starting with the Peet valve and gradually developing into the modern double-disk type of valve in general use to-day?

An objection to the solid-wedge type is the fact that the gates always seat in the same place, and when foreign substance is trapped between the gate and the seats the seats would become so damaged that the gate would leak. In parallel seated or double-disk valves the gates do not seat twice in exactly the same place; in some makes the disks completely revolve, bringing always a different part to the seat. Therefore, should solid matter be caught between the gate and the seats, the marring will not cause serious damage, as the dent in the disk will not come opposite the corresponding one in the seat, and the compensating feature of the parallel seat valve, permitting a certain amount of give, takes care of some irregularities in the contact parts.

Then the difficulty in repairing a bevel-seated valve, the replacing a marred or defective ring, is of quite serious moment. In fact, it is very doubtful whether a solid-wedge valve could be reseated without cutting it out of the pipe, on account of it being almost impossible to get the bevel the correct angle to fit the solid-wedge gate. In other words, it would be necessary to cut a valve out of the pipe and return it to the manufacturers. Whereas, in the case of a parallel seated valve, it is not at all difficult to replace a seat ring when the valve is in the pipe, and should it be necessary to remove it from the pipe, it could be refaced at any general machine shop in the town or city in which the valve is located.

Now, it will be urged that valves are seldom used, and that the wear on the working parts would be very slow in any type of valve. This in the main is true, but does not seem to be a good argument in favor of adopting a valve that will not stand the wear of frequent use, all other things being equal.

Mr. Finneran speaks of the liability of the double-disk type of valve vibrating in operation, opening or closing, because of

the looseness of the disks when unseated. As hereinbefore mentioned, the double-disk and parallel seat valves are made with the least possible lost motion, consequently the looseness is not sufficient to cause serious vibration. The writer, after more than forty years' experience with this type of valve, cannot remember any such action of sufficient violence to be even noticeable. Is it not a fact that the solid wedges are loose, having a considerable play in the grooves, until near their final seat? Surely, if they were a close fit there would be friction between guides and wedge during the entire operation of opening or closing.

The continued improvement in the double-disk type has been so rapid, and the service given by it so satisfactory, that the use of the solid wedge is rarely considered except in old installations, where, probably, the newer type has not been tried.

The writer finds no record of a manufacturer of parallel seated or double-disk valves changing over to the making of the solid-wedge type, while there are a number of makers of solid-wedge valves now making double-disk valves as well as their original type.

One might infer from Mr. Finneran's paper that the double-disk type of valve was rather new, when he says "a number of manufacturers have abandoned the old solid-wedge type plug and taken up with the many kinds of loose double disks." It is true that most of the manufacturers who commenced with the solid-wedge type are now making the double-disk valves also; but there are several manufacturers who have never made anything but double-disk or parallel seat valves, and some of them have been in business over half a century.

DISCUSSION.

MR. FINNERAN. I understood Mr. Diven to say in his paper that about the only time that a double-disk valve is exposed to frictional resistance is while opening or raising. I find in my experience that considerable frictional resistance is encountered in closing or going down. When closing a valve, because of a break in the main, with a flow of water out through the opening, an unbalanced pressure is encountered that tends to force the

wedge with great stress towards the opposite seat. As the wedge descends into the water-way with an increasing area exposed to pressure, a correspondingly increased frictional resistance has to be overcome. This friction or drag is on the guides until the wedge has almost reached the bottom, when it is transferred to the seat opposite the direction of pressure.

Mr. Diven expressed some doubt as to the practicability of having the angle of taper correspond in the wedge and seats. That is easily accomplished in manufacture by having a special angle or taper plate fixed to the lathe so that plugs and seats will have their faces cut at exactly the same taper.

Then, again, he speaks about the rubbing of the rings; I presume he refers to abrasion caused by foreign substances in the seats. Generally speaking, valves in distribution systems are not operated very often — an average of once a month is high. I know of valves that, except as a matter of maintenance or test, are not operated once a year. So I do not apprehend much danger from that source. Furthermore, the solid wedge, because of its taper, does not come in contact with the seats except during the end of its descent or the beginning of its ascent.

In considering the relative merits of solid wedge and loose double-disk types of valves, I am impressed with the proposition that there is practically but one seat to a valve in operation. By an unbalanced pressure and a small amount of play in the guides the wedge is forced tightly against that one seat. What is the use of an additional seating necessitating the extra force required to overcome the unbalanced pressure and to expand both disks to a double seating?

Mr. Diven. Mr. Finneran goes back to the very proposition that the speaker brought out, and that is, the fact that valves are infrequently used is no reason for adopting a valve that will not stand frequent use. Of course in a distribution system many valves, except for their annual or semi-annual or possibly more frequent tests, are not used from year's end to year's end. Possibly some of them are never used in actual service. But in filter plants and pumping stations valves are used with great frequency. The speaker has a 30-in. valve in use which is used from once to twice a day changing water from a storage reservoir first into

the low service and then into the middle service. That is a double-seat type of valve, and has been in use since 1905 without any repairs whatever. The speaker's experience with trouble with valves is, of course, the same as everybody else's, — that the most trouble is in the stem. But the great argument in favor of the double-disk valve is that the wear and strain of use comes on the rugged wedge rather than on the delicate seat of the valve or the seat-ring, which, to the speaker's mind, is really the most delicate part of the valve, the part that we depend on for water-tightness. Of course we all know how troublesome leaky valves are. We have to go back and take in another section, and people that have to have short notice complain; in fact, the shutting off of the water is a disagreeable thing for the water-works manager anyhow, and the less of it we can do, the better.

Mr. Weston E. Fuller.* Probably the most severe use that valves in filtration plants get is on the wash-water lines of mechanical filters. The speaker has recently had occasion to renew some of the seats on wash-water valves of a mechanical filter which had become badly worn. The wearing in this case was probably increased materially because the valves were used in a partially throttled position, the rush of water through underneath the disks wearing the valve seats very rapidly. The question comes up to-day: What would have happened if these valves were of the solid-wedge type? The ones I am speaking of were double-disk valves. Probably the cost of renewing would have been much greater with the solid-wedge type. I would like to hear from others who have had experience with filters that have been in operation ten or twelve years.

Mr. Finneran. One of the greatest troubles with valves is due to the accumulation of rust or other solid material in the recess between both seats of the valve at the bottom. It is quite a problem. If some device could be invented or produced that would eliminate or reduce that accumulation, it would be of great value and much appreciated.

Mr. Diven. Isn't that accomplished in a large measure in our every-day practice by merely closing a valve, opening hydrants or flush-gates on the downstream side, and getting a strong current

* Civil Engineer, New York.

of water under the valve, working down into this chamber, carrying away any collection of sediment.

MR. FINNERAN. In a city where there are about 15 000 valves, it would necessitate quite a little labor to go around every short period and wash out under the wedges of each valve.

MR. DIVEN. We do that only while using the valves. It might be a very good thing to keep them clean, but the speaker has had very little trouble in cleaning out any accumulation of mud with a good and sufficient velocity of water. Perhaps if the entire chamber was lined with bronze the difficulties would be less, but that would make the valves more expensive, and seems unnecessary.

MR. A. O. DOANE.* I have had considerable experience with valves since the beginning of the Metropolitan Water Works, and have had many talks with the late Mr. Brackett on the merits of the double-disk and the wedge valve. He was always very much in favor of the single-wedge valve, on very much the same grounds that Mr. Finneran has taken, and perhaps from the same line of experience, as he was with the Boston Water Works for years. He believed in the simplicity of the wedge type against the complications, or alleged complications, of the double-disk type. My personal experience in the actual operation of valves has been somewhat limited, but I have had considerable experience in following the manufacture, and I believe there are some good points in both systems. That is to say, it is hardly fair to make any general statements condemning either one type or the other. I believe that the solid-wedge type is considerably simpler and that the wedges, as they are generally made, are stronger mechanically than the double-disk type.

With regard to the points that have been brought up, about the wearing of the valves by opening, it seems to me that the valves in both types seat very much the same. That is, when the gate is shut and you open it with unequal pressure on the two sides, in both types the disks or wedges drag over the seats at first. In the wedge type, as we make them, with a very little clearance between the guides in the body and guides in the plug, and a bronze lining in both the wedge and body, then the valve almost imme-

* Division Engineer, Metropolitan Water Works.

diately leaves its seat, being drawn away on account of the small clearance between the guide in the body and the guide in the wedge. So there is comparatively little dragging action. But most commercial valves where the guides are not lined have a large clearance there, so that the wedge type does drag over the seat for a considerable distance when they are opened. Now I think that same thing is true of almost any type of double-disk valve I have seen, as, when either closing or opening under an unequal pressure, the disk does scrape or drag across the seat.

In regard to the abrasion of the seats by gravel, sand, or other grit, it has been my experience in testing valves that a very small particle of grit will ruin the tightness of the valve. In regard to the point being made of the valve seating in a different place in the double-disk type, it does not seem to me that that would ever have much influence, for the action of a particle of grit is to make a score across both seats, probably with slightly raised edges. Now, it does not seem very material whether a disk changes position or not. The scratch is on the seat, and the edges of that scratch are going to keep the disk away from the seat and cause a leak, whether the valve seats in some other place or not.

Concerning the mechanical features of the valves; on the Metropolitan Water Works all valves on the pipe lines are of the wedge type, but there are a few valves of the double-disk type in the pumping stations. The experience we have had with these valves has seemed to me to be ample confirmation of Mr. Brackett's views about the complication of this type, because we have had considerable trouble with these valves, on account of parts giving out. In some cases when we wanted to start up a pumping engine we would find that while the valve is apparently open, only one of the disks was open and the other was down. As that occurred two or three times in a period of ten years it rather confirmed us that our views were right on the wedge principle. We were rather glad we did not have several thousand of them. I know that many of the towns and cities using double-disk valves apparently have no trouble. Perhaps our trouble was rather exceptional in that these valves were operated often.

In regard to operating valves frequently; we had one 36-in. valve of the solid-wedge type with bronze-lined guides and bronze

seats and faces, that was operated from at least two to four times a day for a period of nine years to regulate pressure. The valve was not tight as it was usually kept a few inches open, and the water had worn the seats considerably, yet after a period of nine years all that had to be replaced was the stem and the stem nut, because the threads were worn out. It simply meant a new stem and stem-nut, at a comparatively small expense, to put the valve in service again.

With regard to the manufacture of the valves, the question has been raised about their interchangeability. There seems to be no difficulty in the present shop practice in any single manufacturer making valves that are absolutely interchangeable. The practice of the large manufacturers is to machine the seats and faces of the valves on a boring-mill. The flanges or faces of the bells are machined first and are then placed on taper-plates having exactly the same angle that is used in both the body of the valve and the wedge. The wedges are machined to gages which limit the thickness so that there is no trouble whatever in taking a wedge out of any gate and putting it into another gate, or reversing the wedge in the same gate and having it tight.

I will agree that when it comes to repairing the seats, theoretically anyhow, the double-disk type is easier to repair, — as worn seats and disks may sometimes be renewed without removing the gate from the pipe line, though one of the prominent manufacturers of double-disk gates has told me that it generally comes to a case of sending the valve back to them, after all, if it is a large valve, and particularly a valve that has been in use a long time.

Mr. Diven. The speaker was very much interested in what Mr. Doane said about one disk dropping down and leaving the other up. That, in any type of double-disk valve the speaker has examined, would be an impossibility. If anything happened to let one disk down, both would go.

He also spoke about the damage from scoring and seating in the same place making no difference. The metal of the ring and the seat are, as far as the speaker knows, the same, and would score equally. With the valve seating always in the same place, those two scored portions would come opposite each other, and there

would be double the leakage that there would with a revolving disk not seating in the same place.

As to the interchangeability of parts, while they may have the machinery in the shop perfected, in use the wear would be on the seat as well as on the plug, and any standard plug put in would not fit the worn seat. It seems as though the plug would have to be ground to fit that particular seat to make up for the wear or else a new seat put in with the plug.

A matter that was brought to the speaker's attention was a case in point, where the wedging sprung the body of the valve a considerable amount. This did not cause a leak, it being the double-disk type of valve, the flexibility of the valve made up for this. But with a solid-wedge valve this would be just as apt to occur, and there would be no take-up to it. Of course we will all concede that the body of the valve should not spring. It should be made so that it will not.

MR. DOANE. With regard to the scratches coming opposite; it is undoubtedly the fact that if we could imagine that there is a score of perhaps one one-hundredth of an inch across the seat of the disk, and the valve seats right to a mathematical line, — then those two scores would come opposite. But I think in the ordinary valve it would be a thousand chances against one that that wedge could ever be put down in position so that those two scores would come opposite each other again.

Concerning the point that was raised about a valve body springing, that the double-disk valve would take care of it better: That may very likely be so if the valve springs considerably more than any well-designed valve should, but with our wedge type of valve, even with the small clearance that we allow, we have never found any difficulty about the wedge having clearance enough to deflect the very small distance required to make the seat tight. There is a type of solid-wedge valve made that has a central portion cast solid between the two disks and then the spring of the disks under the water pressure takes care of any spring of the body. That has worked out quite successfully and depends entirely on the elasticity of the cast iron. There are no loose parts in the wedge at all.

MR. W. C. HAWLEY.* We use the double-disk type of valves

* Chief Engineer, Pennsylvania Water Company, Wilkinsburg, Pa.

at our filter plant. They have been in service now a little over five years and we have had no trouble with them. The first water plant I had anything to do with was finished twenty-nine years ago. We used the double-disk valves there and those valves are still in service, and so far as I know have given no trouble. In our own plant we are using the double-disk valves. We have used one type now for nearly thirty years and we have no trouble with the scoring of the disks or the seats. The weak point is the stem. I think that is where we have most trouble with our valves. I have had no experience with the solid wedge valve except two 8-in. valves that were put on a large pumping engine and operated on a by-pass under a pressure of about 250 or 260 lbs. Those valves failed inside of a year. We replaced them with the double-disk type and they have been in constant use ever since, about ten years, and we have had no trouble with them at all.

I think we ought not to lose sight of the fact that there are two distinct types of double-disk valves, one in which the disks come down opposite the seats and are then wedged apart against the seats, and the other where the disks wedge into place against the seats as they are forced down. I do not purchase valves of the latter type, as I believe that the former is the better design. My experience has been entirely with that type of valve.

Mr. John H. Gregory.* I might mention an experience with solid-wedge valves which came under my observation a few years ago. Some eight or ten 36-in. valves designed for about 100 lbs. service pressure were tested under 125 or 130 lbs. pressure. The specifications under which the valves were purchased provided that the manufacturer should submit his own designs, and the valves were made in accordance with these designs. The valves were tested with a blank flange first on one end and then on the other end, and finally, with blank flanges on both ends. The valves were supposed to have been made heavy enough to stand the test pressure, but as a matter of fact the bodies were not strong enough and the valves leaked when tested in the shop. The manufacturer replaced the valves with heavier ones, making the bodies very much heavier so as to be stiff enough not to distort under pressure. With a solid-wedge valve the body should either be

* Of Hering and Gregory, New York.

stiff enough not to distort appreciably under pressure, or else the wedge gate should be designed to distort so as to follow the distortion of the body.

In the Columbus plant the valves are of the solid-wedge type, and, as far as I know, up to the present time no trouble has been experienced with them. The plant was started in operation about seven years ago, and the last time that I visited the plant I did not hear that any repairs had been made to the valves.

MR. FRANK C. KIMBALL.* In regard to the action or the working of gates in filter plants, we had a mechanical filtration plant in Knoxville, Tenn., that was installed in 1895, where certain gates had to be operated for washing, from perhaps a maximum of four times a day to a minimum of once every two days. The last I had to do with that plant was in 1909, — about fourteen years after it was constructed, — and without stating definitely, to the best of my knowledge none of those gates had been replaced at that time, and with the exception of two or three stems, no repairs had been made upon them. These were of the double-disk and wedge pattern. What has happened since 1909 to these valves, I cannot state.

MR. WESTON E. FULLER. The case I mentioned where the seats on the wash-water valves had to be renewed was with the use of water for washing purposes under a pressure of 70 lb., so that the conditions were quite different from those in a filter plant where low-pressure water is used for washing. Under the high pressure the valves were throttled down so much that a very high velocity resulted under the disks, with a consequent tendency for wear. I may say that these valves were used for some twelve years under these rather unusual conditions before the seats were renewed.

MR. ROBERT J. THOMAS.† Every superintendent of water works has had a lot of trouble with all kinds of valves. It is not a question of a satisfactory gate. It is rather a question which type of gate will give the least trouble. For that reason I regret that the manufacturers of valves are not present so that they might learn something about how the valves work in practice. They have not had the experience in operating valves that water-works

* General Manager Commonwealth Water and Light Company, Summit, N. J.
† Superintendent of Water Works, Lowell, Mass.

superintendents have, in making extensions, alterations, etc. It is very seldom that you can find a tight valve. If you have five or six valves off, there is sure to be one of them leaking. We all know what a lot of trouble that means. If the manufacturers knew all the trouble that leaky valves cause the water-works superintendents and water takers, they would, I am sure, try to do something better for us. Sometimes, owing to defective valves, it is necessary to shut off a greater area than should be necessary, forcing the conclusion that you cannot have any too many valves. The old idea that a valve on every line of street was enough, you will find is not right, when you go to use that valve, especially if it has been in use probably thirty-five to forty years, for it will not close down tight. Therefore you have to go to another valve, another block away. I have told our men in putting in valves lately to put in about twice as many as were formerly thought necessary so that if one gave out we would have another one near by to fall back upon. We are putting valves now on all of the hydrant branches, and the underwriters require it because of the fact that the valves are not to be depended upon. In pumping stations, where valves are operated often, it is very easy to determine which is the best working valve. Take a valve that has been closed for several years, on a blow-off from a force main. When you come to open it you will find, if it is a solid-wedge type of valve, that it is impossible to operate. I have found it so. You may break the stem, but it takes quite a while to get a new one. My experience has been that all valves give more or less trouble. But we have had to replace by far more valves of the solid-wedge type than we did of the double-disk. I notice at different places throughout the country where they are putting in filter plants that most of the valves, the big valves, are of the double-disk pattern. I suppose they favored that pattern only after investigation and study being convinced it was the best. It may be different in Boston, where they make their own valves. Maybe they make the solid-wedge type of valve better than manufacturers do. I do not know any other explanation why that type of valve works more satisfactorily there than it does in other places, unless it is because they make a better valve than the manufacturers do.

MR. W. C. TANNATT, JR.* In Easthampton we have just about an equal amount of double-wedge valves and solid-wedge valves, and I find that the biggest trouble with ours is the sediment accumulating underneath the seat will not allow the valve to seat properly. I have also found that in working the valve up and down it is easier to free a solid-wedge valve than it is a double-wedge valve. In replacing valves we have made it a rule now to discard the double-wedge valves in favor of the solid wedge.

MR. DANIEL A. MCCRUDDEN.† I agree with Mr. Thomas that the wedge type of valve is really much harder to open after it has been left closed for ten or fifteen years, as quite often happens, and there is much more trouble with it than with the other type of valve. There are quite a few valves in a system that have to remain closed on account of a difference in pressure. They are very rarely operated except in case of trouble on one system, when it is desirable to take water from the other. In such a connection, a wedge type of valve is far superior to the other type.

We have, I dare say, about 28 000 wedge-type valves, and quite often the closed valves cause trouble. But as far as the sediment at the bottom is concerned, there is only one way to remedy it, and that is the precaution we have taken of operating the big valves every three months, and all valves on the system at least part way at least once a year. That will remedy the trouble of sediment in the bottom. Of course it is a big job to operate all of the valves in the town once a year, and we have not gotten it yet. We are trying to.

MR. FRANK L. FULLER. The Wellesley works were built about thirty years ago, and the large majority of the valves put in were the double-disk type, and I have never heard any complaint in regard to them. From time to time solid-wedge valves have been used, and I have no further knowledge about them. In other works with which I have been connected it has been sometimes one type and sometimes the other, and as a general thing I think they have worked satisfactorily. Much trouble comes from the accumulation of sand and grit under the gates when they are opened and shut in flushing the pipe system, when the works are

* Easthampton, Mass.
† Purveyor, Bureau of Water, Philadelphia.

new, and from grit and gravel being caught between the valve and seat. In this way they become cut and scratched and in consequence leak. It is very necessary, I think, that the pipes should be thoroughly flushed and all the grit in the valves removed. The valves should be put in closed and as the water is gradually let on from one line of pipe to another these valves should be opened, as necessary, and the pipes thoroughly flushed by opening hydrants. The water should be drawn out, as long as there is any indication of grit and gravel, and a good deal of water passed through the pipes, to be sure that they are thoroughly cleaned. If that is done, either type of valve will be satisfactory.

MR. PATRICK GEAR.* For sixteen years before I became superintendent in Holyoke I had been out fixing the gates when they were broken, making the spindles for them, taking them apart, and putting the spindles in, and finding fault with the maker of the gates because he did not make them right. I still keep finding fault with him because he has not improved them any.

Now what trouble did we find with the old gate that we got in the system forty years ago? We have the same trouble to-day. One speaker says if the gates are operated once a year or oftener we will get away from the sediment in the bottom, but if there are 40 000 gates there, the people would say there is an awful waste of money, operating those gates every day and stirring up and making the water dirty for the laundrymen and the washwomen. I say if the manufacturer makes the gate properly we won't have any trouble in shutting the gate down and making it tight. I sympathize with the man who is around trying to sell the gate, because when we find fault with him and tell him it is no good because it hasn't this, that, or the other, and he goes back to the manufacturer and says, "So-and-so of such a town told me it ought to be done so," they say, "Why, he doesn't know what he is talking about." That is what they will tell him. If the gate is made with a good space at the bottom of it, a couple of inches — I don't care what size the gate is — perhaps two or three inches in the bottom — and have the brass ring stick out a half of an inch so that it would not be right up against the cast iron, there would not be any trouble with sediment. I have taken gates apart that

* Superintendent of Water Works, Holyoke, Mass.

have been in for forty years, and when I have taken them out, taken out the rust, and put in a new spindle, they were as good as ever. If they were made properly at first they would be all right. Now the spindle in a 6-in. gate is $1\frac{1}{4}$-in. in diameter, but at the bottom of the thread it is about $\frac{7}{8}$-in. Did you ever know of a spindle to break around the stuffing-box? I never did. They always break at the bottom, between the nut and the shoulder. Just as soon as they put the strength where it belongs we will have less trouble, but when they are putting the strength in the spindle where it never is needed, it is no good to us. They are talking about the double valve and single one. The men who sell the double one will tell you it is better. One gentleman said, a little while ago, that one side of the double disk might lift up before the other. There is one gentleman selling that type and he says it is good because it will give a lift of one side before the other. There may be something to it. But I know we have got both of them and we have got trouble with them. And it is all up to the manufacturer. Now, if the gentlemen from Boston made the gates, they should be perfectly satisfactory. I know if I were making them I would guarantee I would never have trouble.

Mr. Daniel A. McCrudden. I believe that operating valves is the biggest advantage you can have and the best way to spend money. A gang of three men in one district has operated over 6 000 valves in three months. The first time they operated those valves it took six months. The last time it took just three months, showing how far superior our valves are in that district than they were a little over a year ago, when we can do it in half the time it did take us previously. We have in that district about two hundred 36- to 48-in. valves and we can do that work in something like four days. When I was in that district two years ago, to operate, repair our big valves, it took me something like three months to get around those one hundred fifty valves and put them in good condition. But they are doing it now in four days out of every three months, with a gang of three men, where I had to have at times eight and ten men to move the valves. So I think it is well paid work.

Mr. Gear. I want the spindle and stuffing box improved, and then you won't have trouble in operating the gates, — if it is idle

ten years. I found a gate once when it took three or four men to open it. I dug it up and found there was a cast-iron stuffing box, and a cast-iron gland in that gate. They were stuck so that you couldn't move it. When I took them apart and cleaned them, the gate was all right. Now, if valves could be made with a brass stuffing box, brass nuts and bolts, brass gland, and a brass lining on the top of the gate where the shoulder of the spindle rests, you will never find a gate stuck in forty years. The trouble comes there. You won't find trouble operating a gate made in this way, and you won't have any leaks either.

MR. A. E. MARTIN. If the purchasing agents of the different cities would pay a little more attention to the quality of the gates they buy instead of the price, our manufacturers would build the gates that are needed. The superintendent knows what he wants, but when he goes up against a purchasing agent who, bound to make good in his department, insists on giving his order to the lowest bidder, he does not always get the best. The manufacturer has got to build for the purchasing agent and not for the superintendent.

MR. FINNERAN (*by letter*). I have recently examined a number of valves which have had varying lengths of service, some with fifty years or more, and I noticed little or no injury to the rings or plugs due to abrasion. I found in some of the old valves that the rings were displaced, as the iron backing had rusted away, leaving them without support. Some double-disk valves showed much wear in the trunnions, particularly one that had been near a locomotive standpipe. The plug can be removed without difficulty from any type of valve without disconnecting it from the pipe line, but the seat ring cannot be. It seems important, therefore, to give more attention to the method of securing the seat rings. A variety of methods are used; in our practice the rings are driven into slots and pinned.

While I think that both types of valves depend upon good materials and workmanship to give satisfactory service, I believe that the simplicity of the solid-wedge type, with its few moving parts, commends itself for long periods of general service.

WIRE FENCES AND CONCRETE POSTS.

BY RALPH N. WHEELER, DEPARTMENT ENGINEER OF THE BOARD OF WATER SUPPLY, NEW YORK.

[*Read September 8, 1915.*]

Many miles of wire fencing on concrete posts have been erected during the last three years to define lines of property taken for the Catskill aqueduct and reservoirs, and to mark rights-of-way and road crossings over city property, all the work being done by contract. The purpose of this paper is to call attention to some of the points to be observed in order to get the best results in constructing fences of this type.

Several cross-sections were used for posts, all reinforced, the posts generally tapering from the bottom toward the top. For the so-called line post the T-section, reinforced with three No. 5 gage wire rods, was most generally used, but on some parts of the work a D-section reinforced by four similar wires was preferred. D-posts being built under an existing contract have four $\frac{1}{4}$-in. twisted rods. The line posts were generally 7 ft. 3 in. long, and made to set 2.5 to 3 ft. in earth and not less than 1.75 ft. in rock. For straining, gate and latch posts, the square cross-section was used, reinforced with four $\frac{1}{4}$-in. or $\frac{1}{2}$-in. square twisted rods, depending on the length of the post. No ornamental tops were used, the only attempt at ornamentation being to provide pyramid tops for hinge and latch posts.

All posts were cast in thin sheet metal forms in horizontal position. The D or T sections were assembled by the battery or table method. The battery method employs a small steel car with hinged ends, so designed as to permit the placing and filling of five layers of six molds each; the table method makes use of a skeleton table on which the molds are placed. Both methods provide for tightly closing the ends of the molds. Preference is expressed for the table method, as the faces of posts are exposed for troweling or rubbing at the proper time. Slightly more floor

area is, however, required. Objections to the battery method are the drip from the upper layers, which tends to pit the faces of posts below, and the impracticability of troweling or rubbing the faces. Joggling, essential for properly expelling the air, is accomplished by shaking the skeleton table or moving the battery car back and forward along its track.

To secure good posts with either method the following points must be observed:

1. Molds should be coated with a thin film of oil.

2. Concrete aggregates should be of two sizes, well graded; the fine up to $\frac{1}{4}$ in., and the coarse from $\frac{1}{4}$ to $\frac{1}{2}$ in. for the smaller sections of post and $\frac{1}{4}$ to $\frac{3}{4}$ in. for the larger.

3. The mixture must be very accurately proportioned, analyses being desirable to determine the exact proportions. Generally about one part of cement to three parts by volume of aggregates gave the best results.

4. The concrete must be thoroughly mixed and of wet consistency.

5. The ends of molds must be sealed tightly with clay, plaster of Paris, or cement, to insure good tops.

6. The air must be expelled by joggling and running a trowel back and forth through the mixture and along the sides of the mold while placing.

7. The reinforcement must be placed in correct position. This can be accomplished without a spacing device after a workman becomes skilled.

8. The reinforcing metal, particularly round wires, should be thoroughly rusted or nicked to give a proper bond. Bending the ends of these wires back 180 degrees gave good results. As received from the mill, these wires were greasy from the drawing process, and it was found necessary to hasten rusting by the use of a weak acid afterward neutralized. Posts tested to failure showed that unrusted straight wires would pull through, whereas properly rusted ones, or those with ends bent, would break. It has been suggested that running the wire through a barbing machine such as is used in the manufacture of barbed wire nails would deform it sufficiently to give a good bond. This would add not over one-half cent per pound to the cost.

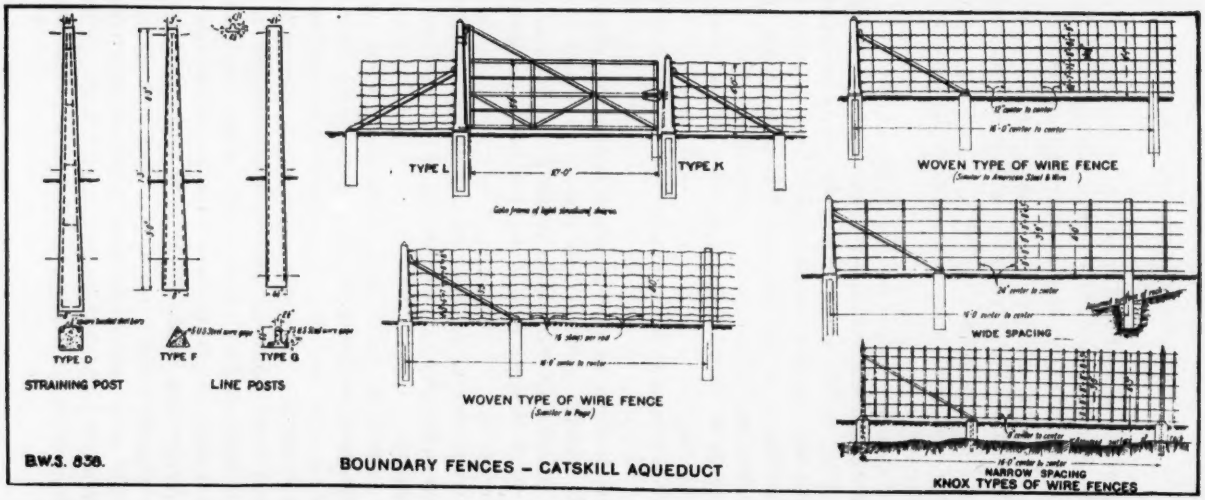

TYPE D
TYPE F
TYPE G
STRAINING POST
LINE POSTS
TYPE L
TYPE K
WOVEN TYPE OF WIRE FENCE
WOVEN TYPE OF WIRE FENCE
WIDE SPACING
NARROW SPACING
KNOX TYPES OF WIRE FENCES
B.W.S. 838.
BOUNDARY FENCES – CATSKILL AQUEDUCT

FIG. 1.

9. Posts must be properly cured. They can be removed from the molds in thirty-six hours, and may then be stood in a vertical position and water sprayed over them from suitably arranged piping, or preferably they may be spaced in a horizontal position and covered with sand or sawdust kept wet. Curing should cover at least two weeks, and better four.

10. The rounding of edges of the exposed face can be accomplished in the form, but better by rubbing with a carborundum brick after erection and before the wire is stretched. If fencing is attached by wrapping wires, rough edges assist in holding the wires.

The T-section posts weigh 90 to 100 lb. each and require very careful handling. They were transported from the casting yard to the work in spring wagons or trucks, generally about forty posts to the load. Tests showed that the strength of the T-post was greatly increased by substituting three $\frac{1}{4}$-in. twisted rods for the three No. 5 gage wires, the weight of the reinforcing metal being practically doubled by the change.

Posts were set not less than 30 in. in the ground, and efforts were made to secure a pleasing profile of the tops. It was found very desirable to place stones in the holes around the bottoms of posts and to thoroughly tamp the refill. In swampy ground and where the fence line was curved, posts were generally concreted in, as otherwise the strain of the fencing would throw them out of line. It was found desirable not to set posts in filled ground, as on right-of-way banks, until the filling had stood through at least one winter.

Straining posts were placed at irregular intervals to suit the topography and alignment, but never exceeding 600 ft. apart. The average interval was somewhat less than 300 ft. Early experience proved that such posts should be concreted in. Two permanent angle iron braces were generally used on straining posts, but in case the angle in the line made this impracticable, a straining post was set at the angle point and another 16 ft. away, each provided with a single brace. The proper location of straining posts is of great importance if a tight, good-looking fence is desired. Therefore special study of this detail is necessary. Early in the work concrete brace bases were cast and set in position to support the lower end of the angle iron brace. Better

results were secured later by digging a hole and filling same with concrete, in which the lower end of the brace was set. Gate and latch posts were generally set in concrete, this method proving more effective in preserving alignment. All property line posts were set with the face on the proper line; in other words, the posts are entirely on city property.

Two general types of fencing were used, namely, factory and field woven, the use of the former being more general. Both types were No. 7 gage throughout and had seven horizontal strands, all heavily galvanized. The field-woven fencing was of the Knox type, with pickets spaced either 8 in. or 24 in. This type was used in more conspicuous locations, or over very irregular ground. The factory-woven fencing, made by the American Steel & Wire Co., was delivered in 20-rod rolls, and weighed about 1.1 lb. per foot. The weight of Knox fencing with 24-in. spacing of pickets is about the same. For erecting factory-woven fence, stretching, wrapping, cutting, and crimping tools were required. For erecting the Knox type, a pair of light blocks was required for controlling the strain in each horizontal wire, also a special tool for fastening the pickets to these wires. Many methods of fastening fencing to posts were considered; the following one was finally adopted and successfully used. At end, corner, and straining posts the horizontal line wires were carried around the posts and wrapped on themselves, interfering verticals being cut out and the fencing kept under strain while this wrapping was being done. At line posts short wrapping wires, first of No. 12 and later of No. 9 gage, were used. These wires were delivered in bundles, each wire straight and long enough to make two wraps. They were cut into proper lengths, one cut giving the pieces for wrapping the top and bottom horizontal wires, another the second and fifth, etc., thus avoiding any waste. Two men generally worked together attaching these wires. The operation was performed as follows: A short bend was first made near one end, giving sufficient material for wrapping four times around the horizontal wire; it was then placed in position snugly against the side of the post and wrapped. The loose end was then carried snugly around the post and wrapped four times around the line wire on the other side. Care must be taken to keep the wrap in the horizontal plane of the line wire and to have it tight and snug

FIG. 1.
FENCE GATE WITH CHAIN FOR LOCKING; DETAILS OF BRACING THE GATE; AND MANWAY POST.

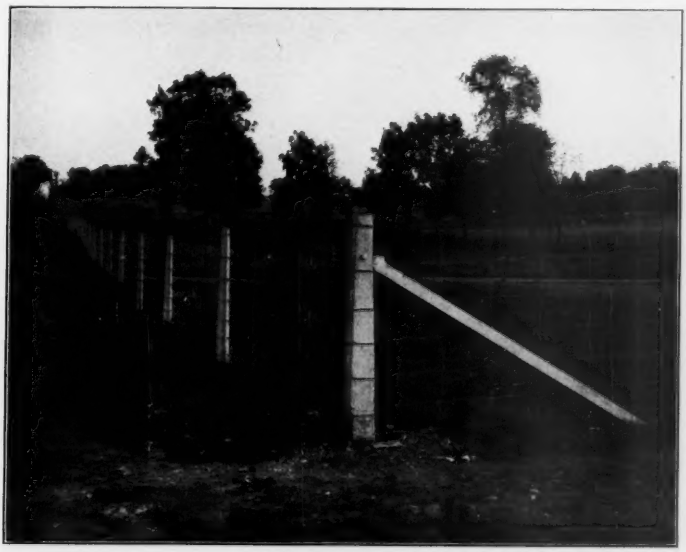


FIG. 2.
STANDARD CORNER CONSTRUCTION WITH SQUARE CONCRETE POST BRACED IN TWO DIRECTIONS BY STEEL ANGLE-IRON BRACES.

against the post. Done in this way, the fencing cannot be lifted up, and the batter of the post prevents sagging. This method of wrapping is preferred because it does away with special attachment pieces or holes in the posts, permits the stringing of wire any distance above the ground or below the top of post, and is economical. Wrapping tools can be bought for a few cents each from fencing manufacturers, or can be made by a handy blacksmith. Fencing was erected during practically every month of the year. Probably better results were secured from the warm weather work, although this undoubtedly caused more of a strain on the posts due to contraction in the colder months.

Galvanized angle irons 2 in. by 2 in. by $\frac{1}{4}$ in. by 7 ft., or $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{1}{4}$ in. by 9 ft., were used for braces; these were bent to fit the side of the post at one end and the concrete anchorage at the other, with holes at each end for attachment. The better way is to bend the upper ends of these braces at a sharp radius with a slotted hole where bolted to the posts to permit adjustment on sloping ground. The bottom ends can be simply bent down and concreted into the brace block. However, even this type of brace cannot be conveniently cut to length in the field, and those contemplating erection of fences should consider braces of $1\frac{1}{2}$ in. galvanized pipe. These can easily be made up in the field to special lengths, and the use of couplings prevents wasting short pieces. One end should be flattened down for four or five inches, bent to the desired shape, and drilled for the bolt connection. The other end is bent slightly and concreted into the anchorage or flattened and secured to a bolt in the anchorage. It is understood that reinforced concrete braces instead of angle irons have been used in the outskirts of Brooklyn for the wire fencing along the Sea Beach route of the new subway system put in operation this summer.

Gates generally 10 ft. long, made of angles and flats, were used freely in the line and right-of-way fences. A somewhat wider gate opening seems desirable. The top support is made adjustable, and all hinge supports, top supports, latch plates, and bolts are heavily galvanized. This is desirable when the difficulty of securing a good paint for exposed metal work is considered. Gates are locked by inserting the tongue of a small brass padlock through a hole drilled in the latch.

Experience to date has indicated no likelihood of trouble with the posts, although adjustments of gates and their supporting posts have been necessary, particularly on field rights-of-way. Early in the work the posts offered tempting targets to hunters, but it is believed the novelty has worn off. Frequently, too, some country Hercules would try the strength of the posts after erection and before wires were strung, by pulling back and forth, generally with disaster to the post. Once the wire is strung this danger is removed. The importance of securing dense, smooth tops is obvious, as disintegration by frost action is thereby reduced or eliminated.

It appears to the writer undesirable to attach fencing to either the hinge or latch post of a gate, as sooner or later the strain throws the gate out of line and adjustments are necessary. It is better to set extra posts, one of which should be spaced for a manway. Manway openings should not be too wide, particularly in regions where live stock is pastured. It is better to make them so that a man must turn sideways and then contract as much as possible to get through; in other words, the opening should not exceed 14 in. at the top if the posts taper; if not, the opening should not exceed 12 in. The T-section post, from its peculiar shape, is particularly firm in the ground, but above ground it does not look much like a post. The writer suggests for consideration the use of a post of combination section; that is, made up of a T-section below the ground and a D-section above. In this way a maximum of rigidity will be secured, and at the same time a section above ground which resembles in appearance an ordinary post.

The cost of fences erected by contract along the Catskill Aqueduct was approximately as follows:

Line fence with straining post and two braces every 300 ft., and line posts at 16-ft. intervals —

Factory-woven type, 16c to 20c per foot.

Knox or field-woven type, 19c to 22c per foot.

Typical right-of-way, approximately 200 ft. long, with the straining and special posts, braces, and gates incidental thereto, 39c to 42c per foot.

The type of fencing affected the cost of rights-of-way very little.

GROUTING OR CUSHIONING STANDPIPE BASES.

BY CHARLES W. SHERMAN.*

[*Read November 10, 1915.*]

Probably the most common method of transmitting the pressure from the bottom of a standpipe to the masonry or concrete foundation is by means of a sand cushion or, in some cases, a cushion of sand mixed with cement. Without such a supporting layer it is obvious that the empty tank would rest upon the rivet heads, and when filled the plates between the rivets would be bent in such a way that a considerable part of the plates would come in direct contact with the foundation.

As far as transmitting the loads from the plates to the foundation is concerned, there is no material criticism of the sand cushion. It is a fact, however, that even with the best of workmanship, the bottom of the standpipe is not absolutely flat. Certain plates or parts of plates will bulge either up or down. Those parts which bulge up, or "dome," will not rest upon the sand cushion when the tank is empty, as the sand cannot be caused to flow enough to fill these empty spaces, and the confined air has no opportunity to escape. When the tank is filled with water, the plate is bent down into contact with the sand, but when the tank is emptied the plate will spring back to its original position.

It is, of course, impossible to get at the under side of the bottom of the tank for cleaning and painting, and it is therefore of importance that the material with which the plate comes in contact should have a preservative action upon the metal. It is well known that hydraulic cement has such a preservative action. Probably for this reason it has been customary in many cases to mix dry cement with the sand cushion, on the supposition that in the course of time slight leaks in the bottom plate, or water absorbed from the atmosphere or by capillarity through the foundation, may be sufficient to cause the cement to set. It is obvious,

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

however, that if the cement should set, when the tank is empty the domed places in the bottom plate would again spring back to their original position, leaving voids between the metal and the cushion.

As an alternative method, it has been attempted in some cases to grout the space between the bottom plate and the foundation by pouring cement grout through holes left in the bottom plate, these holes being afterward stopped by iron plugs. Although it is somewhat difficult to fill all the voids under the bottom plate by this method, without forcing in the grout under so great a pressure as to lift the bottom plate itself, nevertheless it is possible, by careful work, to substantially fill the entire space. When the bottom is well grouted in this way the plate should be in intimate contact with the cement mortar through its entire extent, and accordingly should be subject to the preservative action of the cement.

This paper has been suggested by a recent experience in grouting the bottom of the new Bird's Hill standpipe for the town of Needham, Mass. This tank is 55 ft. in diameter and 44 ft. in height, and rests on a foundation of cement concrete.

In this case the holes for grouting were arbitrarily spaced 10 ft. apart in both directions. This spacing was unfortunate, as it left a few plates without any grouting holes whatever in them, and in several cases brought the holes close to the seams between the plates. The holes were 2 in. in diameter and were fitted with 2-in. pipe 2 ft. in length and with threaded plugs.

The grout was made of a 1 to 1 mixture of cement and screened sand, using sufficient water to make it of the consistency of cream, and was poured from coal hods into tin funnels inserted in the tops of the pipes. A stick about $\frac{3}{4}$-in. in diameter and somewhat uneven was worked up and down in the grouting pipe while the grout was being poured, thus assisting in keeping the grout well mixed and in causing it to flow freely through the pipe.

The experience in pouring the grout varied considerably. In some cases the grout would flow freely to a long distance from the hole through which it was poured; in others, it could not be made to run more than a short distance. In one case, at least, the grout flowed to a distance of 7 ft. on one side and 8 ft. on the opposite

side of a particular hole. In one case where the grouting hole was located close to a seam the grout apparently did not flow past the seam at all; in another similar case the grout not only passed the seam but flowed freely for a distance of three or four feet beyond it.

It was found practicable to determine closely the extent of the filling beneath the plate by pounding upon the bottom with a heavy stick. When the grout at last ceased to flow from any pipe, it was apparently due to a stoppage at the bottom of the pipe itself, and there was no evidence that hydrostatic pressure was transmitted to any distance around the pipe in such a manner as to tend to lift the bottom plate.

As previously stated, the spacing of the grouting holes was somewhat unfortunate, and we were not successful in completely filling the space beneath the bottom plate from the holes originally drilled. We did, however, succeed in filling nearly all of the space, and used 132 bags of cement in the grout poured through the original 27 holes. By pounding the bottom after this work was completed, the points where additional grouting was required were determined, and were marked. Additional holes are to be drilled at these points and the grouting continued, and we anticipate no difficulty in satisfactorily completing the work.

If the points for the grout pipes had been located upon the bottom in advance of drilling, instead of being arbitrarily placed at a fixed distance apart, there would probably have been no difficulty in completing the job from the first set of holes. The holes should have been so located that there would be at least one in every plate; they should be located approximately axially upon the center line of the plate, and also in the high spots of the bottom, if any exist.

A different method of insuring that the bottom of a standpipe is in perfect contact with the foundation has been employed by Mr. William Wheeler, of Boston, in twelve or fourteen cases, and with entire satisfaction. This method consists in constructing the bottom of the tank in the form of an inverted cone. In Mr. Wheeler's practice the altitude of this cone has been uniformly 2 ft., and this method has been used on tanks as large as 40 ft. in diameter.

It is obvious that the conical form possesses the advantage of being able to resist pressure from beneath, without deformation,

so that it is possible to put in grout under pressure without in any way lifting the bottom, and also that there is no opportunity for air pockets. In setting these tanks it has been Mr. Wheeler's practice to lower them into final position about 2 in. above the previously constructed masonry foundation, and to fill the 2-in. space with a 1 to 1 mortar mixed rather wet and forced into place by a long, thin rammer, working from the outside.

It is interesting to note that Mr. Wheeler had occasion, a few years ago, to raise one of the standpipes constructed in this manner, from its original base, and found the under side of the bottom plates as clean and free from corrosion as when originally received from the mills.

THE WAKEFIELD WATER STERILIZATION PLANT.

BY EDWARD C. SHERMAN.*

[*Read November 10, 1915.*]

The only chlorine gas plant used for the sterilization of a municipal water supply in Massachusetts is the one in Wakefield, which was put in regular use on September 1, 1914, after several weeks of preliminary testing.

Wakefield, with a population of some 13 000, has a surface water supply, taken from Crystal Lake in the outskirts of the town and pumped directly into the mains, a standpipe serving to take the surplus and to afford a night supply, the pumps being run about eight hours a day. A considerable part of the watershed is under cultivation, and much of the resident population is without sewers, so that heavy rains wash a good deal of organic matter into the lake, raising the bacterial content very considerably and at times causing dangerous contamination.

While it is indisputable that filtration is the only method by which such a supply can be rendered always satisfactory in bacterial quality and in appearance, the expense of installing filters was not considered by the water board to be justifiable, as they estimate that the growth of the town will make a new source of supply necessary in from ten to fifteen years. Indeed, it is probable that the capacity of Crystal Lake would have been reached by now had not the introduction of meters on services resulted in checking the waste of water and in reducing the per-capita consumption to about 48 gal. per day.

The board therefore asked me to recommend to them some inexpensive means by which the water could be kept safe for domestic use even though the physical characteristics remained unchanged, provided any such means were available. Sterilization would of course accomplish that result, and I recommended the use of chlorine gas on account of the simplicity of operating the apparatus

*Of Rourke & Sherman, Consulting Engineers, Boston.

and of applying the chemical to the water. My recommendations were adopted and a plant was purchased from the Electro-Bleaching Gas Company of New York.

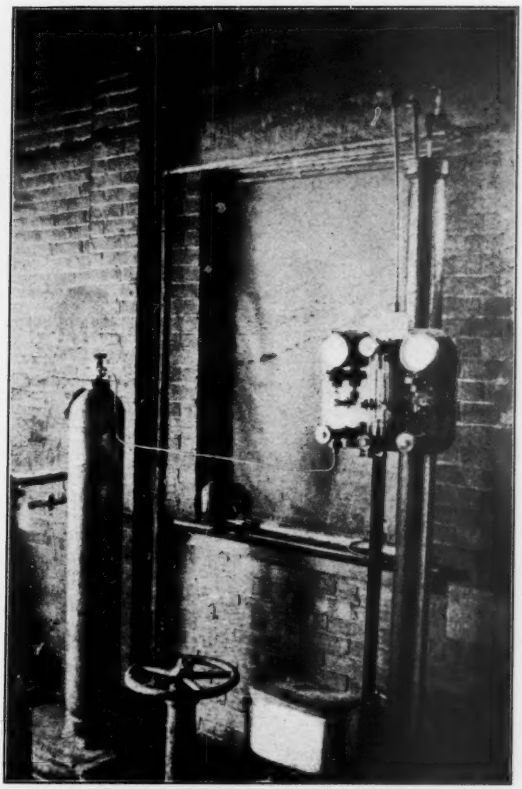
The apparatus consists of a tank, containing chlorine in liquid form; a control board for the necessary valves and gages; and an absorption tower. Opening the valves on the tank and the control panel permits some of the chlorine to vaporize and pass through a copper tube to a reducing valve, where the pressure is changed from the tank pressure of perhaps 100 lb. per sq. in. to 6 or 7 lb. per sq. in. The high and low pressures are shown by gages mounted on the board. The gas then passes through a rate-control valve and enters the tower, where it is absorbed by a small spray of water. The chlorine solution thus formed is then drawn into the suction pipe and is mixed with the supply while passing through the pump.

The rate of pumping being very nearly constant, fluctuations in the consumption being taken care of by the standpipe, the rate of application of the chlorine is satisfactorily controlled by hand, changes in the valve setting seldom being necessary except when required by a change in the quality of the water being treated.

The rate-control gage, which shows the amount of chlorine being used in ounces per hour, consists of a conical glass tube, small end down, containing a peculiarly shaped platinum float which is free to move up and down in it. The gas, in passing upward through the tube, flows through the annular space around the float and raises it to the point where the area of the opening is sufficiently great. The tube is calibrated, and a graduated card, set behind it, indicates the rate of flow for any position of the float. The rate of using the gas is checked by readings of the weight of the tank, which stands on platform scales, and from the records showing the hours of pumping.

A small water tank, provided with a float valve and connected with the absorption tower, maintains a supply of water at a fixed depth in the bottom of the tower. The water for absorbing the chlorine is supplied through a small pipe leading to the top of the tower.

During the first year of the operation of the plant under my direction, — ending September 1, 1915, — 75 samples of raw water and 107 samples of treated water from taps in Wakefield were collected



VIEW OF CHLORINE CONTROL APPARATUS.

and examined. Samples were collected at intervals of from one day to a week, depending on the results of previous analyses and on the weather. The examinations, which were made in the laboratory of Mr. Robert Spurr Weston, indicated that the treated water was continuously safe.

The number of bacteria in the lake water has varied from a minimum of only 30 per c.c. in August, 1915, to a maximum of 1420 per c.c. in January, 1915, just after a hard, warm rain had removed a considerable accumulation of snow and ice from the watershed.

The number of bacteria in the treated water has seldom been above 30 per c.c., the maximum being 56 and the minimum 1 per c.c. In January, on the day when the lake was in its worst condition, we found only 16 per c.c. in the treated water. For the year the averages were, for Crystal Lake, 254 per c.c., and for the supply as delivered to the consumers, 18 per c.c., — an average removal of 93 per cent.

The averages for each month were as shown in the following table.

Year.	Month.	Crystal Lake.		Tap Water.	
		Number of Samples.	Average No. of Bacteria per c.c.	Number of Samples.	Average No. of Bacteria per c.c.
1914	September	12	89	16	10
	October	5	81	10	16
	November	4	81	5	16
	December	6	56	10	9
1915	January	17	625	19	14
	February	10	220	11	24
	March	4	181	9	33
	April	4	149	6	23
	May	3	172	5	24
	June	2	285	4	15
	July	4	308	6	31
	August	4	111	6	16

B. coli were found in 17 per cent. of the raw water samples and in none of the treated water samples, the counts being made on 10 c.c.

To secure these results the amount of chlorine has varied from

a minimum of one part to 2 000 000 parts of water, in December, 1914, to a maximum of 1 part in about 800 000 parts of water for a very short time in January, 1915. The water at this time contained a large amount of organic matter, much of it of a harmless

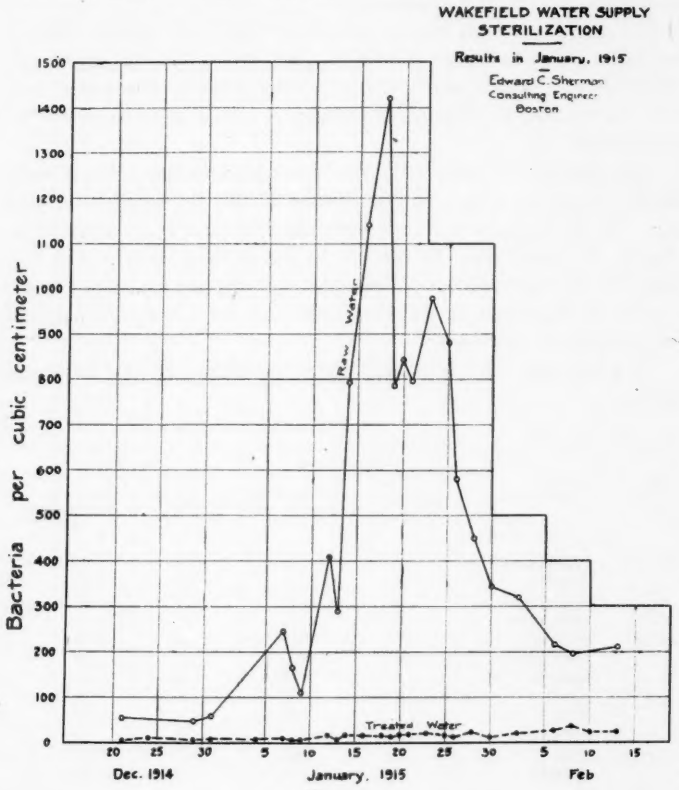


FIG. 1.

nature, but it made necessary an unusually large dose of disinfectant in order to get the desired effect on the bacteria. If the water could be clarified by rapid filtration prior to the sterilization, it is probable that even better results could be secured and with less chlorine.

The cost of the plant in place was about $600. The present cost of operating it, including chlorine, supervision of operation, and interest is approximately $1.25 per million gallons. For the year, and including the cost of the almost constant supervision when the plant was first started and at times when the raw water was bad, the cost averaged about $1.75 per million gallons.

Although the results of the use of chlorine have been good in Wakefield, it must be remembered that no method of sterilization can remove turbidity or much of the color, so it can never take the place of filtration. Of the cynical who may advance the argument that the success of the treatment is dependent on the faithfulness and intelligence of those in charge, I can only ask if it is not equally true of any other kind of a purification plant. No purification plant will run itself, and the human element must always be considered. However, as it is becoming increasingly more difficult to secure adequate natural supplies of pure water, processes of artificial purification are absolutely necessary and I am convinced that sterilization has its proper place among them and that it is especially valuable for small surface-water supplies, where conditions do not justify the expense of filtration.

DISCUSSION.

MR. JOHN A. KIENLE* (*by letter*). With regard to Mr. Sherman's statement near the end of his paper, that no method of sterilization can remove much color, I wish to call attention to the results which Mr. Robert Spurr Weston obtained at Exeter, N. H., where by the use of liquid chlorine he was enabled to save a considerable quantity of alum which was used there in the filtration plant for the reduction of color, and that by using the chlorine the color was rendered decidedly better than that obtained previously by the use of alum. The results obtained are shown in the following brief tabulation taken from the September, 1914, issue of the American Water Works Association.

	June.	
	1913.	1914.
Color, reservoir	90.0	75.0
Color, effluent	45.0	6.0

*Sanitary Engineer, New York.

A similar experience is reported from St. Catharines, Ont., Mr. Milne advising me that there has been quite a noticeable reduction in the color of the water. I believe that, if this matter were further investigated by competent engineers and chemists, some very interesting data could be obtained. Many of the chlorine gas plants which have been installed are not under scientific supervision, and matters of this kind are seldom considered.

The costs given by Mr. Sherman for sterilizing the Wakefield water are rather higher than the average cost for other plants, due to the high organic content of the Wakefield supply, which necessitates an excessive quantity of chlorine. It is seldom that with raw, unfiltered waters it is necessary to use more than three or four pounds of liquid chlorine per million gallons, giving a cost of less than 50 cents per million gallons; while on filtered waters the average quantity used is less than two pounds per million gallons, corresponding to a maximum cost of about 25 cents per million gallons.

MR. ROBERT S. WESTON.* I might say, in explanation of Mr. Kienle's criticism or discussion, that the two cases, the one at Wakefield and the one at Exeter, are hardly parallel. At Wakefield, chlorine is added to water and nothing further done to it. At Exeter, chlorine is added to the water; then sulphate of alumina is added, and the whole is filtered. While it is true, as Mr. Kienle says, that the addition of chlorine makes better color reduction possible, it is not true that if chlorine alone were added to the Exeter water there would be an appreciable reduction of color unless the water was treated and filtered afterwards.

MR. CALEB M. SAVILLE.† Our experience at Hartford with chlorine gas is that there was quite a little reduction in color.

I would like to ask Mr. Sherman if he had any trouble with aftergrowths in tap water. I would also like to ask what the temperature of the room was in which his apparatus is located, and whether or not he has noticed any differences in the efficiency of the apparatus with variation of temperature.

MR. SHERMAN. In regard to Mr. Kienle's remarks about color removal, we have not made any examinations of the color of the Wakefield water, as it has not been of particular interest. The

* Of Weston & Sampson, Consulting Engineers, Boston.
† Chief Engineer, Water Commission, Hartford, Conn.

sole object of the use of chlorine there has been to reduce the number of bacteria and thereby to make a water which, while not particularly good in appearance, is nevertheless safe to use for drinking. And that I believe we have done. Mr. Kienle also speaks of the amount of chlorine used in Wakefield as excessive compared with some of his figures. It is, perhaps, but we have never had to use an amount which could be detected in the water by taste or smell. His statement that fifty cents per million gallons is a reasonable cost seems to me to be based on the cost of the chlorine only. Now Wakefield has had to pay for the chlorine, of course, but in order to feel sure that we were getting good results, the town has also paid for a large number of analyses, which, of course, are rather expensive, and for engineering supervision, which very few plants, as Mr. Kienle says, have.

In answer to Mr. Saville's inquiry about after-growths, I have not noticed that there has been any trouble in that way. Chlorine is applied to the water just before it goes into the pumps, from which it goes immediately to the mains, and the samples have shown a large and very satisfactory reduction of bacteria. The temperature in the pumping station must be between 80 and 90 degrees, I think, although I have not read a thermometer there. It is always very warm. I am not able to say whether the efficiency is affected by that or not, because the only records that I have are bacterial counts of samples of the raw water and of the treated water taken at the same time.

The efficiency has been about 93 per cent. for the year. This method of recording efficiency by percentages is in some ways unsatisfactory. I think 93 per cent. would perhaps sound low to a filter man who expects to get a removal of 98 or 99 per cent. of the bacteria. If the raw water contains a thousand bacteria per cu. cm. it is easy to get a 99 per cent. reduction, whereas when there are only 200 it is exceedingly difficult.

Mr. Frank L. Fuller.* I would like to inquire whether there is any appreciable precipitation due to this treatment.

Mr. Sherman. I do not see why any should be caused, but there is no way we can tell because the water goes on into the mains and we have no way of measuring it.

* Civil Engineer, Boston.

MR. SAVILLE. Mr. Sherman's apparatus is apparently very favorably situated, and he should have very good results from it. The apparatus that we have at Hartford is located in a small building by itself, and we found that we had to have artificial heat there with it for a great part of the time in order to get the best results.

MR. SHERMAN. The minor water supply which absorbs the chlorine is not warmed except as it may be by passing through a small pipe in the pumping station for a short distance. It flows very slowly, and it may be that the temperature is raised a very little, but I should not imagine that in winter it would be warmed appreciably.

PROCEEDINGS.

Annual Meeting.

Hotel Brunswick,
Boston, Mass., January 12, 1916.

The President, Leonard Metcalf, in the chair.
The following members and guests were present:

Honorary Members.

E. C. Brooks, G. A. Stacy, R. C. P. Coggeshall, A. S. Glover, F. E. Hall, F. P. Stearns. — 6.

Members.

C. L. Baker, L. M. Bancroft, F. S. Bailey, F. A. Barbour, A. E. Blackmer, J. W. Blackmer, George Bowers, Bertram Brewer, James Burnie, George Cassell, J. C. Chase, F. L. Clapp, E. S. Cole, J. E. Conley, John Cullen, J. M. Diven, H. P. Eddy, E. D. Eldredge, A. L. Fales, S. F. Ferguson, G. H. Finneran, F. F. Forbes, Patrick Gear, F. J. Gifford, T. C. Gleason, R. K. Hale, J. O. Hall, D. A. Heffernan, J. L. Howard, A. C. Howes, G. A. Johnson, H. R. Johnson, W. S. Johnson, E. W. Kent, Willard Kent, T. E. Lally, J. B. Longley, E. J. Looney, F. A. McInnes, Hugh McLean, H. V. Macksey, W. E. Maybury, John Mayo, J. H. Mendell, F. E. Merrill, Leonard Metcalf, H. A. Miller, J. W. Murphy, William Naylor, A. S. Negus, T. A. Pierce, C. E. Perry, H. G. Pillsbury, L. C. Robinson, P. R. Sanders, C. M. Saville, C. W. Sherman, E. C. Sherman, H. M. Sinclair, M. A. Sinclair, G. Z. Smith, Sidney Smith, G. H. Snell, C. M. Spofford, F. O. Stevens, W. F. Sullivan, H. A. Symonds, R. J. Thomas, Milton Thorne, J. L. Tighe, A. H. Tillson, D. N. Tower, W. J. Turnbull, J. H. Walsh, R. S. Weston, J. P. Wentworth, G. C. Whipple, O. J. Whitney, F. I. Winslow, G. E. Winslow, I. S. Wood. — 81.

Associates.

Harold L. Bond & Co., G. S. Hodges; Builders Iron Foundry, A. B. Coulters and F. N. Connet; A. M. Byers Co., H. F. Fiske; Chapman Valve Mfg. Co., V. N. Bengle and J. T. Mulgrew; Darling Pump and Mfg. Co., H. A. Snyder; Eddy Valve Co., H. W. Dotten and John Knickerbacker; F. H. Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., A. S. Glover and J. Herman Smith; Lead Lined Iron Pipe Co., T. W. Dwyer; Ludlow Valve Mfg. Co., A. A. Taylor

and G. A. Miller; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., H. L. Weston; Neptune Meter Co., H. H. Kinsey; Norwood Engineering Co., H. W. Hosford and F. M. Sears; Rensselaer Valve Co., C. L. Brown and F. S. Bates; A. P. Smith Mfg. Co., F. L. Northrop; Thomson Meter Co., S. D. Higley and E. M. Shedd; Union Water Meter Co., F. E. Hall; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, Samuel Proctor and W. F. Bird. — 30.

GUESTS.

Thomas F. Dorsey, Edgartown, Mass.; James Kinloch, E. Greenwich, R. I.; Walter Skinner, secretary board of health, Braintree, Mass.; Mr. Collins, Cambridge, Mass.; John A. Carter, Malden, Mass.; F. W. Mathers, Boston; Mass.; G. E. Gormley, Abington, Mass.; George N. Buckhont, Newport, R. I., D. J. Dever, H. D. Coombs, H. S. O'Brien, J. P. Perham, Boston, Mass.; Wm. J. Murray, Rumford, R. I.; Wm. A. Bradford, president South Shore Water Plant, Quincy, Mass.; Mr. Putnam, Lowell, Mass.; C. F. Gettemy, State Board of Statistics, Boston, Mass.; Theodore M. Waddell, Boston, Mass. — 17.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

E. D. Bistline, Newport, Pa., secretary of Hanover & Washington Water Co., Newport Home Water Co., Lebanon Valley Consolidated Water Supply Co., Middletown & Swatara Consolidated Water Co., and other water companies; Edward G. Gushee, Philadelphia, Pa., 2d assistant engineer, Bureau of Water, Philadelphia; George Mitchell, Aberdeen, Scotland, engaged exclusively on water works for twenty-two years, at present principal assistant to city water engineer on a scheme costing £500,000; Fred B. Nelson, New York City, civil and hydraulic engineering; William G. Newhall, Portland, Me., assistant superintendent Portland Water District; James A. Steele, Jr., Vicksburg, Miss., water works for past ten years, at present manager of city water works, Vicksburg, Miss.; Edward Mayo Tolman, Charleston, W. Va., health departments of Massachusetts, Maryland, and West Virginia, chief engineer state department of health, W. Va.; Joseph F. Ranger, Holyoke, Mass., water commissioner, Holyoke, Mass.; Raymond Walker, Edgartown, Mass., superintendent Edgartown Water Co.; John P. Wentworth, Malden, Mass., assistant engineer, Metcalf & Eddy, Boston, Mass.

On motion, duly seconded, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

Report of the Executive Committee.

The President, Mr. Leonard Metcalf, for the Executive Committee, presented the following:

REPORT UPON THE ACTIVITIES OF THE NEW ENGLAND WATER WORKS ASSOCIATION DURING THE YEAR 1915.

Membership.

The Secretary's report indicates that we have now a membership only 39 less than a full thousand.

It is perhaps interesting to note the changes in rate of growth of the Association during various periods. As will be seen from the diagram before you, during the first seventeen years the net rate of increase was fairly uniform, averaging 34 members per year; during the next six years there were considerable losses, due mainly to the increase in annual dues from $2 to $3, and the average net increase was but 5 members per year; then for nine years the increase averaged 17 per year, while during the past two years the average growth has been 102. For the whole 34 years the average net rate of increase was 28 members per year. A considerable portion of the gain for the past year (114) resulted more or less directly from the action of the Association in abating the entrance fee for members of the American Water Works Association joining in the year 1915. Ninety-two members and 8 associates, or 100 in all, took advantage of this offer.

It is believed, however, that the work of the Association is not as thoroughly appreciated, by water departments and water boards in many of the smaller communities of New England, as it should be; and that further effort, which must be largely of a personal nature, could and should be made, in the interest alike of the public and of the Association, to reach these men and boards, with a view to further extending the activities and usefu work of the Association.

Deaths.

The Association has lost, by death, during the year, the fol'owing members: H. H. Barnes, Dexter Brackett, Eben R. Dwyer, E. A. Ellsworth, John H. Flynn, W. A. McFarland, Thomas F. Richardson, J. Herbert Shedd, J. F. Sprenkell, Francis P. Washburn, and E. P. Whitten.

Meetings.

The usual number of meetings has been held and the attendance has been good. The June field day took the form of a joint excursion with the Boston Society of Civil Engineers; and a ball game between teams, representing the two associations, was an important feature. This contest was much enjoyed, and it is believed that a similar plan for future excursions may be advantageous.

The annual convention in New York was very successful, thanks to the efficient work of the able local committee, headed by Alfred D. Flinn, and the friendly coöperation with it of the associates and the Manufacturers Association representatives. The papers were largely of a practical nature and were well received, and the exhibits were excellent.

Papers.

It has been the constant endeavor of your officers to secure papers which should be thoroughly practical. They recognize that the Association exists primarily for the benefit of men engaged in the actual operation of water works, and that the scientist and engineer fit into its activities only as they help along water-works science and art and draw out from the practical water-works men their experiences in the building and operation of water works, which may be of value to their fellow-men.

Committees.

The past reputation of this Association has been won, in considerable measure, by the work of its committees. The work done during the past year compares favorably with that of other years, although none of the existing committees has made its final report

during this period. A brief reference to the work of these committee is perhaps desirable.

The committee on FILTRATION STATISTICS (G. C. Whipple, chairman) made a report which was accepted, in which was outlined a standard form for recording statistics of filter operation. The committee was continued, to work for the adoption and use by filtration plants of the proposed forms. It reports good progress in this direction.

The committee on METER RATES (Allen Hazen, chairman) made a very valuable report, covering the question of rates in an admirable manner. It was continued in order to consider the question of "water-unaccounted-for," and will probably report upon that subject at an early meeting, rendering its final report at that time.

The committee on CAST-IRON PIPE SPECIFICATIONS (F. A. McInnes, chairman), which has been in existence for several years, has devoted itself to an attempt to secure concerted action with a similar committee of the American Water Works Association. Marked advance has been made in bringing the two committees together, to the end of unifying views, and it is believed that substantial progress toward final report will be made in the near future.

The committee on STANDARD HYDRANT SPECIFICATIONS (H. O. Lacount, chairman) reported in 1914 and the suggested specifications were adopted, with the exception of two or three clauses which were referred back to the committee for further consideration. The chairman of the committee reports that effort has been made to get the coöperation of the manufacturers, in presenting or developing further information concerning the size of the valve and the amount of friction loss in hydrants of various makes, without success, and desires expression of opinion as to the further wishes of the Association. It is suggested that further effort be made to obtain the active coöperation of the manufacturers, or, failing in this, that the Association take early action upon the specifications, as outlined by the committee, with a view to advantageous standardization of practice as far as this may prove possible.

The committee on SERVICE PIPES (William S. Johnson, chair-

man) has obtained and tabulated a large amount of information relative to practice in different places and the experiences had with service pipe made of different materials. The data are being analyzed in an attempt to determine the reasons for the variety of experience recorded.

The committee on LEAKAGE FROM PIPE JOINTS (F. A. Barbour, chairman) was appointed in September, and has not yet had time to make marked progress. It has, however, outlined the form of circular to be used in obtaining information, which will be issued in the near future. Members are urged to coöperate conscientiously with the committee, by prompt compliance with requests for information and by furnishing as complete data as possible. The work which the committee is undertaking is of great importance to members of this Association and the public, but its results can be of value only if the necessary information is furnished to the committee.

The committee on BRACKETT MEMORIAL (Frederic P. Stearns, chairman), appointed to procure the necessary funds and to draft rules for the award of a bronze medal to be given annually for the most meritorious paper presented, as a memorial to past-president Dexter Brackett, report that a sufficient fund has already been guaranteed by a few of the members of the Association to assure the success of the memorial, and there will soon be given to the entire membership opportunity to contribute to this memorial which, it is believed, will be welcomed. The contributions are to be purely voluntary and of such amount only as the donors may feel impelled to make. It is thought that Mr. Brackett himself would have felt that no better type of memorial than this could have been suggested.

The Executive Committee has given careful consideration to the subject of LEGISLATIVE COMMITTEES, referred to it at the last meeting. It recommends, however, that action be deferred until the new Executive Committee can consider the subject, and in the meantime it will submit to the new board its tentative conclusions.

Pan-American Scientific Congress.

The Association was represented at the Second Pan-American Scientific Congress, which has just concluded its session at Wash-

ington, by Mr. Alfred D. Flinn, who not only participated in the meetings of the engineering section of the Congress, but presented a paper on "Reservoirs for Municipal Water Supply."

Journal.

This year's volume of the JOURNAL has been the largest since 1910, and is the next to the largest ever published by the Association. It contains 26 papers, some of which were presented at the 1914 convention. It is especially noteworthy as containing Mr. X. H. Goodnough's paper upon "Rainfall in New England." The cost of printing this paper and the report of the committee (of which Mr. Frederic P. Stearns was chairman) upon "Yield of Drainage Areas" was very large, as the former covered 201 pages, chiefly of tabular statistics, and the latter 74 pages, containing many tabulations and diagrams, so that the year's volume has been an unusually expensive one, involving an additional cost of upwards of one thousand dollars. Nevertheless, the publication of these papers is believed to have been fully justified and of great value to the public and those particularly interested in the subjects covered. The excessive cost, which results in a deficit for the year's operations, should therefore not be a matter of regret.

The increased circulation of the JOURNAL, from 953 to 1 079, due to the increase in membership, also involved increased expense.

In a report to your President, the editor, Mr. Richard K. Hale, states that with the present number of meetings and the type of papers presented, it is probable that the size of the JOURNAL will average nearly 600 pages in the future. The committee reports are nearly always expensive, but they have been very valuable to the Association, its members and the public, so that the portion of the annual dues of members, which should be attributable to the JOURNAL, is likely to average more than $1.50 per member as time goes on, unless something is done to increase the revenue. The revenue increase can be reached in two ways, by increase of dues or by increase in advertising. Both of these subjects could be discussed with profit, by the Executive Committee, which will soon be compelled to act upon them.

Finances.

As reported in detail by the Treasurer, Lewis M. Bancroft, the cash balance on hand at the beginning of the year was $3,645.51; the general current receipts for the year amounted to $7,123.84; the interest on bonds and deposits, $214.72, — a total of $7,338.56; the expenditures to $8,569.16; leaving a cash balance on hand at the end of the year of $2,414.91.

The decrease in cash balance is attributable, as already stated, wholly to the excessive cost of the JOURNAL, due to the statistical data contained in two important and valuable papers. Since the Association has received an equivalent in value for the expenditure of these funds, there would seem to be no cause for anxiety over the decrease, as the publication of such statistical reports is not of annual occurrence.

Respectfully submitted,

LEONARD METCALF,
For the Executive Committee.

The Secretary, Mr. Willard Kent, presented his annual report as follows:

REPORT OF THE SECRETARY.

JANUARY 1, 1916.

Mr. President and Gentlemen of the New England Water Works Association,— The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 961, constituted as follows: 18 Honorary, 862 Members, and 81 Associates. That of one year ago was 847, comprised of 11 Honorary, 766 Members, and 70 Associates. A net gain for the year of 114. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1915.	Honorary Members	11		
	Transferred from "Members"	7		
				18
January 1, 1915.	Total Members		766	
	Withdrawals:			
	Resigned	26		
	Dropped	13		

	Died	11			
		—	50		
	Transferred to "Honorary Members"		7	57	
				—	
				709	
	Initiations:				
	January	7			
	February	5			
	March	2			
	June	76			
	September	34			
	November	13			
	December	8			
		—	145		
	Reinstated:				
	Members resigned in '99	1			
	" " " '05	1			
	" " " '14	2			
	" dropped in '05	2			
		—	6		
	Elected 1914, qualified 1915		2	153	
			—	—	862
January 1, 1915.	Total Associates		70		
	Withdrawals:				
	Resigned		1		
			—	69	
	Initiations:				
	June	1			
	September	8			
	November	1			
		—	10		
	Reinstated:				
	Associate resigned in '13	1			
	" " " '14	1	2	12	
		—	—	—	81
					—
January 1, 1916.	Total membership				961
January 1, 1915.	Total membership				847
					—
	Net gain				114

The Secretary has received and paid to the Treasurer, $7 123.84.

Of this amount the

Receipts for initiation fees were	$274.00

From dues of members	$2 560.50		
From dues of members, fractional	41.50		
From dues of members, past	21.00		
		$2 623.00	
From dues of Associates	$1 050.00		
From dues of Associates, fractional	61.50	1 111.50	
Total from dues			$3 734.50
From advertisements			1 755.00
From subscriptions			213.00
From JOURNALS			142.26
From sundries			1 005.08
Total as above			$7 123.84
There is due the Association at this date:			
For advertising			$30.00
For specifications			.30
For certificate			1.50
For subscriptions			18.00
Total amount due			$49.80

Respectfully submitted,

WILLARD KENT, *Secretary.*

REPORT OF THE TREASURER.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$220.61
Initiation fees	$274.00	
Dues	3 734.50	
Total received from members		4 008.50
JOURNAL:		
Advertisements	$1 755.00	
Subscriptions	213.00	
Sale of JOURNALS	142.26	
Sale of reprints	42.00	
Total received from JOURNAL		2 152.26

Year	President.	Membership at End of Year.				Annual Convention.		Receipts for Year.	Expenditures for Year.	Total Balance at End of Year.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	*Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	*Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	*George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 271.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	*Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	692	Springfield, Mass.	Sept. 11–13, '07	5 291.83	4 222.06	4 480.30
1908	Alfred E. Martin	633	49	14	696	Atlantic City, N. J.	Sept. 23–25, '08	5 706.36	7 475.56	†2 711.10
1909	Robert J. Thomas	647	55	13	715	New York, N. Y.	Sept. 8–10, '09	5 305.31	4 566.84	†3 449.57
1910	George A. King	678	56	13	747	Rochester, N. Y.	Sept. 21–23, '10	6 507.08	7 237.60	†2 719.05
1911	Allen Hazen	680	58	12	750	Gloucester, Mass.	Sept. 13–15, '11	6 440.90	6 279.72	†2 880.23
1912	Geo. W. Batchelder	666	53	12	731	Washington, D. C.	Sept. 18–20, '12	6 861.65	5 934.56	†3 807.32
1913	J. Waldo Smith	686	60	12	758	Philadelphia, Pa.	Sept. 10–12, '13	6 122.81	6 533.62	†3 396.51
1914	Frank A. McInnes	766	70	11	847	Boston, Mass.	Sept. 9–11, '14	7 686.17	7 437.17	†3 645.51
1915	Leonard Metcalf	862	81	18	961	New York, N. Y.	Sept. 7–9, '15	7 338.56	8 569.16	§2 414.91

*Deceased. †Does not include $1 815 invested in bonds.

Miscellaneous receipts:		
Sale of "Pipe Specifications"	$20.00	
Dinners	837.00	
Certificates of membership	34.50	
Buttons	2.25	
Miscellaneous	63.44	
Total miscellaneous receipts		$957.19
Total receipts		$7 338.56

Expenditures.

JOURNAL:			
Advertising agent, commission		$225.90	
Plates		187.93	
Printing		3 453.60	
Editor's salary		375.00	
Expense		48.42	
Advance reports		19.00	
Reporting		297.20	
Reprints		160.50	
Envelopes, postage, and mailing		74.88	
			$4 842.43
Office:			
Secretary, salary		$200.00	
Expense		26.35	
Assistant Secretary, salary		600.00	
Expense		293.22	
Rent		400.00	
Printing, stationery, and postage		417.76	
Membership lists		212.75	
			2 150.08
Meetings and Committees:			
Stereopticon		$50.00	
Dinners	$867.50		
Cigars	57.10		
Music	105.00		
Extra menu	10.00		
		1 039.60	
Printing, stationery, and postage		299.11	
Badges		15.14	
Tracings		6.00	
			1 409.85
Treasurer's salary and bond			67.50
Certificates of membership			51.30
Miscellaneous			48.00
			$8 569.16

LEWIS M. BANCROFT, *Treasurer*,
In account with the New England Water Works Association.

RECEIPTS.			EXPENDITURES.		
1915.					
Jan. 1.	Balance on hand	$3 645.51	Bills paid		$8 569.16
	Received of Willard Kent, Secretary	7 123.84			
	Interest on bonds and deposits	214.72	BALANCE ON HAND.		
			People's Savings Bank	$2 000.00	
			Mechanics Savings Bank	372.96	
			First National Bank	40.68	
			Liberty Trust Co.	1.27	
					2 414.91
		$10 984.07			$10 984.07

ASSETS AND LIABILITIES.

ASSETS.			LIABILITIES.	
Cash, balance in banks		$2 414.91		
Bonds Nos. 2642 and 2644, Lake Shore & Mich. So. R. R. 4%, due May 1, 1931. Book value, 1 815.00. Market value		1 887.40	Accounts payable:	
Accounts receivable:			Rent	$100.00
JOURNALS	$18.00		Surplus	4 252.11
Advertising	30.00			
Specifications	.30			
Certificates	1.50			
		49.80		
		$4 352.11		$4 352.11

READING, January 8, 1916.

LEWIS M. BANCROFT, *Treasurer*.

The Editor, Mr. Richard K. Hale, submitted the following report:

Report of the Editor.

Boston, January 12, 1916.

To the New England Water Works Association, — I present the following report for the Journal of the New England Water Works Association for the year 1915.

The accompanying tabulated statements show in detail the amount of material in the Journal; the receipts and expenditures on account of Volume XXIX (1915), and a comparison with the conditions of preceding years.

Size of Volume. — With the exception of Volume XXIV, this is the largest volume yet published.

Illustrations. — The total cost of illustrations for the year, including printing, has been $406.43, or 9.6 per cent. of the gross cost of the volume, which is about the average.

Reprints. — The usual number of reprints has been furnished to authors without charge, and additional reprints when desired have been furnished at cost. The net cost to the Association on this account has been $160.50, which is about normal.

Advance Copies. — Advance copies of one paper only have been published, at a cost of $10.50.

Advertisements. — There has been an average of 25 pages of paid advertising, with an income of $1 755, a considerable increase over last year.

Circulation. — The present circulation of the Journal is:

Members	961
Subscribers	87
Exchanges	31
Total	1 079

an increase of 126 over the preceding year. Journals have also been sent to 43 advertisers.

Pipe Specifications. — During the year specifications to the value of $20.20 have been sold. None has been printed during the year. The net gain up to a year ago had been $274.05, so that the total gain net from this source to date is $294.25. There are on hand about 225 copies.

The Association has a credit of $4.19 at the Boston Post-Office, being the balance of the money deposited for payment of postage upon the Journal at pound rates.

There are no outstanding bills, on account of the Journal, which are not included in these tables.

Respectfully submitted,

RICHARD K. HALE, *Editor.*

TABLE 1.

STATEMENT OF MATERIAL IN VOLUME XXIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1915.

Number.	Date.	Pages of								Total Cuts.
		Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Inset Plates.	Total Pages.	
1	March	120	27	147	1	28	4	2	182	4
2	June	77	11	88	1	28	4	20	141	39
3	September	202	41	243	1	28	4	3	279	9
4	December	96	22	118	8	31	4	13	174	29
	Total	495	101	596	11	115	16	38	776	81

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1915.

Receipts.		*Expenditures.*	
Advertisements	$1 755.00	Printing JOURNAL	$2 757.94
Sale of JOURNALS	142.26	Printing illustrations	212.50
Sale of reprints	42.00	Preparing illustrations,	193.93
Subscriptions	213.00	Editor's salary	300.00
	$2 152.26	Editor's incidentals	37.23
Net cost of volume	2 091.09	Advertising agent's commissions	231.35
		Reporting	297.40
		Reprints	202.50
		Advance copies	10.50
	$4 243.35		$4 243.35

TABLE 3.

Comparision between Volumes XX to XXIX, Inclusive, New England Water Works Association.

	Vol. XX. 1906.	Vol. XXI. 1907.	Vol. XXII. 1908.	Vol. XXIII. 1909.	Vol. XX V. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.	Vol. XXIX. 1915.
Average edition (copies printed)	900	1 085	1 000	1 000	1 150	1 000	1 000	1 000	1 050	1 325
Average membership	665	693	699	710	732	752	740	745	803	904
Circulation at end of year	767	785	780	802	827	840	826	858	951	1 079
Pages of text	495	500	500	459	643	475	401	554	564	596
Pages of text per 1 000 members	745	722	715	646	880	632	542	746	702	659
Total pages, all kinds	662	669	681	627	808	654	567	733	719	776
Total pages per 1 000 members	995	964	976	884	1 090	870	766	984	895	859
Gross Cost:										
Total	$2 573.61	$2 643.42	$2 733.61	$3 111.15	$3 490.81	$2 625.87	$2 476.55	$3 586.29	$3 345.87	$4 243.35
Per page	3.88	3.95	4.01	4.97	4.32	4.02	4.37	4.89	4.65	5.47
Per member	3.87	3.82	3.91	4.39	4.78	3.50	3.35	4.81	4.17	4.68
Per member per 1 000 pages	5.85	5.70	5.88	7.00	5.90	4.09	5.90	6.46	5.80	6.02
Per member per 1 000 pages text	7.81	7.62	8.02	9.56	7.44	7.36	8.35	8.68	7.39	7.85
Net Cost:										
Total	$387.96	$483.15	$131.06	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33	$2 091.09
Per page	.58	.72	.19	1.26	1.65	.54	.17	1.80	1.61	2.70
Per member	.58	.70	.19	1.11	1.82	.47	.13	1.78	1.44	2.32
Per member per 1 000 pages	.88	1.04	.28	1.78	2.25	.55	.23	2.42	2.00	2.98
Per member per 1 000 pages text	1.18	1.39	.39	2.43	2.83	.98	.33	2.38	2.55	3.88

TABLE 4.

COMPARISON OF THE MATERIAL IN VOLUMES XX TO XXIX INCLUSIVE.

Year.	Total Text.	Miscellaneous.	Advertisements.	Plates.	Total Pages.	Total Cuts.
1906	495	23	115	29	662	41
1907	500	24	125	20	669	97
1908	500	24	118	39	691	47
1909	459	23	108	37	627	28
1910	643	28	119	18	808	38
1911	475	25	128	26	654	57
1912	401	24	120	22	567	53
1913	554	27	117	35	733	118
1914	564	23	119	13	719	55
1915	596	27	115	38	776	81

Mr. George H. Finneran submitted the following report for the Auditing Committee:

REPORT OF AUDITING COMMITTEE.

BOSTON, MASS., January 11, 1916.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers.

Respectfully submitted,

A. R. HATHAWAY,
BY G. H. F. AND A. L. S.,
ALBERT L. SAWYER,
GEORGE H. FINNERAN,
Auditing Committee.

On motion of Mr. George A. Stacy, it was voted that the foregoing reports of the officers and committees be accepted, placed on file, and printed in the JOURNAL.

The President then delivered the following address.

Some Observations upon the Control of Public Utility Companies by Public-Service Commissions.

Presidential Address delivered before the New England Water Works Association, January 12, 1916, by Leonard Metcalf.

During the past two years, the speaker has chanced to be engaged upon problems relating to the practical control of public utilities by public-service commissions and regulating boards, more particularly of certain water works, and to hear from many others of their experiences in this field of public activity. In view of the belief that the control of public utilities by public-service commissions, or like regulating boards, is probably the best solution of the present-day issues between the public and the corporation, it may perhaps be of interest to point out some of the good features and discuss some of the dangers that have developed or been indicated by practice in the past five to ten years, and the possible remedies for them.

GOOD FEATURES OF COMMISSION CONTROL.

The good features of commission control are so apparent as to require little comment. They have been realized in large measure, but in varying degrees in different places, depending upon the personnel and viewpoint of the commission, the facilities and funds available to it, the attitude of the corporation, and the past as well as present conditions and limitations surrounding the operation of the utilities. Briefly, they may be summed up under the following heads:

1. Wholesome publicity, — giving to the public the truth with regard to the operations of the utilities. This has served to lay bare the position and plans of the corporations and to prevent abuse of privilege. It has also served to bring home to the public in an authoritative and credible manner the difficulties under which the corporations sometimes operate.
2. Enforcing adequate service. In this respect the commissions have been of service in the case of over-capitalized properties, and have helped to prevent an intolerant attitude toward the public on the part of the corporation where such tendency existed. On the other hand, they have brought home to the public that extensions of service sometimes fail to yield fair return for some years after construction.

3. Establishing just rates. This is probably the most important and far-reaching service which the public utility commissions are performing to-day. The task is a very delicate one, involving not only tolerance and judicial spirit, but painstaking study of past conditions, breadth of experience, and knowledge concerning construction and operating conditions and costs.

4. Reducing the hazard and thus increasing the stability of investment by preventing an intolerant position on the part of the corporation or of the public, — thus enabling the corporation to borrow money for its necessary extensions at rates more advantageous alike to the corporation and public. A striking example of the greater stability of public utility securities resulting from commission control is to be found in the state of Wisconsin, as a result of the work of the Wisconsin Railroad Commission.

5. Curbing undesirable exploitation and preventing inflation of securities and estimated values, — thus helping to protect the innocent investor from loss growing out of his inability to thoroughly post himself concerning the real value of the securities offered by corporations.

Many examples might be cited to illustrate these and other less important good features of commission control, but the arguments are so well known and the object lessons have been so common as to make it unnecessary to detail them here.

DANGERS OF COMMISSION CONTROL.

Politics. The dangers of commission control are most often traceable to one source, — the intrusion of politics, — the bringing of political or corporate pressure to bear upon individuals where judicial considerations alone should govern; though the question of proper viewpoint for the commission, as to its relation to the public and to the utilities, and as to desirable limits of control, are important factors, — dependent as they are, not alone upon sound economics but the local psychological atmosphere created by the past relations, good, bad, or indifferent, between the public and the corporation.

The Lack of Experience in the construction and operation of public utilities — of some who have been appointed to the commissions, and more particularly of some of the engineering staffs appointed by them — has already resulted at times in litigation

and expense which would have been avoided had these men but had greater experience in the actual difficulties and hazards of construction and operation. The good motives of these men are not here questioned or at issue, but merely the injustice which may unwittingly be done by such, through lack of experience, and the ultimate cost resulting to the public.

Lack of Available Resources and Uncertain Tenure in Office. In this respect the commissions have been seriously hampered through lack of appropriations to command the services of men of mature judgment and breadth of experience in the operation as well as the design and construction of public utilities. Moreover, the uncertain tenure of office in such work has sometimes militated against the commissions and the public.

Burdensome Cost of Litigation. The lack of breadth of experience of men employed by the commissions in the valuation of public utility properties sometimes causes burdensome expense of litigation. This results from the fact that men of experience can arrive often at results, by methods of approximation growing out of the breadth of their knowledge and experience, which would be equitable, authoritative and acceptable and which would tend to limit the extent and cost of preparation of evidence by the corporations and the public for presentation before the commission, and subsequently before the Federal Court, to narrow limits, whereas, with lack of experience on the part of the commission or of its staff, the corporations and the representatives of the public feel it necessary to present evidence in far greater detail, coupled with comparative analyses of experiences had elsewhere, in the hope of making clear to the inexperienced reviewer the force of their claims. It is clear that, if appealed cases become numerous, the cost of the utilities' service to the public will necessarily be increased thereby, as experience in past trials of valuation and rating cases before the courts has demonstrated the burdensome character of the expense involved. Thus, in water-works valuation and rating cases, the joint expenses of trial to the parties at issue have often amounted to from ten to fifteen per cent. of the total value of the property, sometimes exceeding the higher amount in cases involving small plants, and being somewhat less than the lower in those involving the larger. Clearly, such expenses, though

often unavoidable, involve economic waste, as these funds could much better be applied to improving the property and character of the service than to paying the expenses of litigation, unless the latter serve to bring about a new and better era in the feelings toward one another of the parties at issue. Not only have courts, commissions, and arbitration boards recognized the burdensome character of this expense, but even the lawyers and experts called upon to assist in the conduct of these suits, and conscientious effort has generally been made by the latter to eliminate by agreement, in advance of the trial, as many of the issues at bar as possible, with a view to decreasing unnecessary expense. Often it happens in court trials that, while both parties may in good faith desire to bring about such agreement, the political situation may make it practically impossible to undertake it without running the danger of possibly having the subsequent decision called into question by reason of such joint effort. In these cases, the public utilities commissions are in a position to be of marked service to the parties at issue.

Innovations in Methods of Trial to Save Time and Expense. Some interesting and significant departures have been made from the ordinary legal methods of trial with a view to decreasing the expenses involved in such litigation. Thus, in the valuation of the water-works property of the Macon Gas, Light and Water Company, the board of seven arbitrators, consisting of five engineers and two bankers, outlined and adopted the following course of procedure in the interest of economy of time and expense. First, counsel opened with an historic sketch of the situation; second, the witnesses of the corporation and then of the city stated their qualifications, the nature and extent of their investigations, and their findings, briefly and without the intervention of counsel, either in direct or cross examination; third, counsel on both sides then discussed intangible or semi-intangible values, and, finally, any witnesses desired were recalled by the board at the request of counsel on either side, for cross-examination.

The program outlined proved acceptable to the parties at issue, and as a result of its adoption, the trial was concluded in a two weeks' period at a cost of about three per cent. of the amount of the award, instead of fifteen per cent. (more or less) which might

have resulted had the ordinary legal methods of procedure been followed.

Similarly, the procedure before some of the public utilities commissions is conducted on informal lines, instead of by categorical question and answer with explanation, and the witness is interrupted by the members of the commission at will in order to make clear, as they arise, any doubtful points and to bring home to the witness any considerations overlooked, which might influence his judgment.

More recently (1915) the Master in Chancery of the Federal Court of the District of California, Hon. H. M. Wright, in the trial of the Spring Valley Water Company rating cases at San Francisco, modified the ordinary order and methods of court procedure; first, by hearing all of the evidence upon real estate values before admitting evidence upon structural values; second, in hearing the evidence upon structural plant, by having all of the experts give their evidence, simply and in the form of a connected story unaided by counsel, upon a single group of property,— such, for instance, as earth dams, or pumps, or conduits,— and by permitting counsel to cross-examine the witnesses after the giving of this testimony and before taking up the next class of items. Incidentally, the experts upon the one side were at liberty to question the experts of the other and to assist the court by statements of their own experience, — in the nature of rebuttal, in reply to and as tending to meet the statements of the other experts. The plan has worked admirably, and the Master has already given expression to the opinion that the time consumed has probably not been over one third to one half as great as it would have been if the ordinary methods of court procedure had been followed. Furthermore, it is believed that the Master was thus put into the position to form judgment fairly conclusively upon the various phases of the case under trial, as the evidence was adduced and while the subject was still freshly in mind, instead of being obliged to carry an enormous mass of detail and review the previous testimony, as becomes necessary in ordinary methods of court procedure in important cases long under trial.

In a recent hearing before Judge Sessions at Grand Rapids, upon the suit of Ann Arbor *v.* State of Michigan, the court limited the

introduction of evidence and expenditure of time in the trial, by limiting the cross-examination practically to questions touching upon the qualifications of the witnesses, their honesty of purpose, the soundness of the theories advanced by them, and the major items (only) entering into the estimates of the engineers, — refusing to consider petty items as likely to have little effect upon the decision. The trial was concluded in six days, which is certainly a remarkably brief hearing for a case involving property values of ten million dollars, more or less. It is of significance, however, as indicating the viewpoint of the court upon methods of trial and the desirability of considering these problems upon broad lines, rather than in petty detail, which again brings into prominence the necessity for the review of such questions by men of breadth of experience in the construction and operation of such properties.

Another departure which has been suggested is to be found in the appointment, by the court, of a disinterested engineer of experience to aid it in the formation of sound judgment, in effect calling the engineer to sit upon the bench with the judge to pass upon technical matters and to aid in limiting the lines of investigation to matters of fundamental importance and weight.

The observations here made upon court trials apply in certain respects to trial by commission, and serve to accentuate the desirability of having competent engineers as well as lawyers and business men appointed to our public utilities commissions. The engineering, as well as the legal, point of view is of great importance in assisting to an expeditious and equitable solution of public utilities problems.

Dictation of Operating Policy v. *Simple Control.* The relative desirability of virtual dictation of operation policy, rather than simple control by the commission, and the determination of desirable limits of control, raise difficult and delicate questions which can only be settled in judicial spirit after careful study, open-minded discussion on both sides and, in some cases perhaps, actual trial. Obviously, control implies a certain amount of dictation. The question therefore resolves itself into one as to the extent of control which may prove most advantageous in the long run to the public interest. Equitably, the larger the measure of control exercised, the greater should be the financial responsibility of the

dictator. If our commissions are to dictate policies they will require greater opportunity, better facilities, and far greater financial support to form and exercise sound, far-sighted judgment. If they then dictate the policies to be pursued in management of the public utilities, the corporations should be relieved of the hazard incident to the enforcement of these policies. If, on the other hand, the corporations are still to be made to bear all responsibility and hazard, they should be given reasonable latitude in determining policies and the demands of future service, and should be accorded rates of return commensurate with the hazards involved in their business.

The Failure to Place Adequate Value upon Public Utility Properties, or to make proper allowance for appreciation in value; the elimination of portions of the property from the rating base, as not actively and immediately necessary to the service of the public; and the reduction of the rates to a point which will not produce a return fairly commensurate with the hazard of the business and in keeping with rates of return prevailing thereabout in other classes of enterprise, — all carry with them real dangers to the public, the character and ultimate result of which the public little realizes. Thus, if the difference in value between the mere assemblage of the structures and real estate, "the bare bones of the property," and the living, going concern, with established profitable business, — which it has involved time, effort and real cost to develop, — is not fully recognized; if spare machinery, reserve structures and reserve properties held for the service of the public or bought for use in the reasonably near future, are excluded from the rating base; or if the rate of return fails to provide reasonable depreciation allowance as well as fair return commensurate with actual hazard, — the final result is much the same. The commission may temporarily determine operation and values even to confiscation of a portion of the property value and cutting off of the market for the corporations' securities, but in the long run economic principles will control and the inevitable cycle will follow:

1st. Declining service resulting from failure to keep the property up, — just as the rentor of a farm may take, not only his profit out of the land but its actual ability to produce.

2d. Inadequate service, growing out of service standards neces-

sarily lowered for want of proper return, — just as the exhaustion of the soil of the farm results in lessened future crops.

3d. Inability to borrow new capital upon as advantageous terms, and more aggravated operating and service conditions than theretofore, — similar to the conditions prevailing when the soil of the farm is worked out.

4th. The disadvantages may go even to the actual inability to make good the errors of earlier operating policy, without largely increased cost. Thus in the semi-arid or arid regions, unless water rights are bought considerably in advance of the demands of the community, by the time they are actually needed they may acquire virtual monopoly prices growing out of their utilization for other purposes, and a totally different scheme of construction and operation may have to be followed at substantially greater expense than that which might have been followed had the necessary rights but been acquired at an earlier date. It is obvious, however, that, if earnings are to be denied for considerable periods of time upon such property, public utilities will not care to hazard their investments by having to carry them, without return, for long periods of time.

The public, or the commission, would find itself, therefore, under such conditions, face to face with the necessity of increasing the rating base or the permitted rate of return; with costly litigation; or with the necessity for embarking upon municipal or government ownership. A wiser course for the newly established public-service commission to pursue would seem to be that followed by the New Jersey Public Service Commission in the well-known Passaic Gas case, in which it endeavored to fully recognize values as of the date of its first value determination, and then defined the future method of accounting value and of determining or limiting the fair rate of return; thus giving to the owners of the property the opportunity to transfer their interest into other investments, if they were not content with the commission's future program.

Public Ownership Not the Goal. If public ownership is the real goal sought, a directer method of approach would effect a saving in the ultimate cost of acquisition of the desired properties. But various recent occurrences indicate that the general public is by no means prepared, as yet, to embark upon municipal or government ownership and operation of public utilities, generally or upon a large scale.

Rates. It is well recognized by intelligent managers that the public will more cheerfully pay liberal rates for adequate service than lower or even inadequate rates for bad service. Under normal operating conditions the rule is, " Look to your service first. Fair rates will follow," — though it is equally true that good service cannot long follow inadequate return.

THE REMEDIES.

Promising remedies for the dangers and abuses cited may be summed up as —

1. Non-political appointments and freedom from political or corporate pressure or control for the public-service commissions and their staffs.
2. Long tenure in office.
3. Higher salaries, — adequate to attract and hold men experienced in corporate affairs and in the construction and operation of public utilities.
4. As brief and direct methods as possible of establishing value and fair rate of return.
5. Reasonable regulation or control of the utilities by the commissions rather than dictation of operating policies.
6. Broad and fairly liberal treatment of the question of value and fair rate of return, particularly in the transition stage from no regulation to full control.
7. Support by the public of disinterested and sound findings in public-utility disputes made by competent tribunals, commissions, or men, — whether these findings bear heavily upon the corporation or fail to meet public expectation.

The positions upon the commissions and their staffs are no sinecures. They demand sturdy, fearless character, judicial spirit, and breadth of training and experience.

Let us not underestimate the difficulty of the task or belittle the work of the conscientious men now struggling with this important problem. There are many of them, and they deserve the thoughtful regard and frank support of this and other like organizations.

On the other hand, the dangers of the situation and the penalty involved in unfair standards, either upon the part of the public utility, the public which it serves, or the public-service commission

— which should stand in a strictly judicial position between the two — is not to be ignored.

The writer is conscious that in the foregoing illustrations he has perhaps over-emphasized the dangers to the corporation, as compared to the benefits to the public, to be attained by competent regulation of utilities by public-service commissions. This somewhat unbalanced presentation has followed in part as a result of some recent experiences, and in part because the direct advantage to the public of the commission's powers to curb the corporations is more evident. This latter function is so prominent that many people have a tendency to lose sight of the judicial or impartial stand which commissions should take, and to think of them mainly, if not solely, as agencies for reducing rates.

The true function of a public-service commission is to act as a referee, charged with seeing, on the one hand, that the public has to pay no more than a fair price for the service rendered, and that it receive service of the character for which it pays; and with seeing, on the other hand, that the utility receive fair treatment and compensation. The public, and the corporation as well, can derive benefit only from the regulation of utilities by an able and impartial commission.

This is equally a fact whether the utilities be owned by corporations or by the public themselves; and the writer would not be surprised to see the jurisdiction of the commissions more generally extended in the near future to cover matters relating to the accounting, financing, and making of rates of municipally owned utilities.

Mr. William A. Bradford, president of the South Shore Master Plumbers Association, Quincy, Mass., then presented a paper entitled, "Causes of Explosions of Domestic Boilers." The paper was illustrated by stereopticon views. On motion of Mr. Coggeshall, the thanks of the Association were extended to Mr. Bradford and he was invited to attend the February meeting, to which time the discussion of the paper was postponed.

Mr. Charles W. Sherman read a paper by C. W. Sherman, William S. Johnson, and Henry A. Symonds, on "Municipal

Water Works Financing in Massachusetts as Affected by Recent Legislation."

The subject was discussed by Mr. Charles F. Gettemy, director of the State Bureau of Statistics, and Mr. T. M. Waddell, chief of the Municipal Division of the Bureau.

On motion of Mr. Coggeshall, a vote of thanks was extended to these gentlemen for attending the meeting and expressing their views upon the subject under discussion.

Election of Officers.

Mr. Arthur E. Blackmer submitted the following report of the Tellers appointed to canvass ballots for officers for the ensuing year:

Whole number of ballots	364
Blank	3

President.

William F. Sullivan	346
Scattering	2

Vice-Presidents.

Caleb M. Saville	349
Carleton E. Davis	354
Samuel E. Killam	351
R. S. Lea	349
D. A. Heffernan	349
W. W. Brush	354
Scattering	2

Secretary.

Willard Kent	356

Treasurer.

Lewis M. Bancroft	356

Editor.

Richard K. Hale	355
Scattering	1

Advertising Agent.

GEORGE A. KING 359

Additional Members Executive Committee.

R. C. P. COGGESHALL 355
ROBERT J. THOMAS 355
FRANK J. GIFFORD 351
Scattering 1

Finance Committee.

GEORGE H. FINNERAN 350
D. N. TOWER 352
JOHN MAYO 352
Scattering 2

Respectfully submitted,

ARTHUR E. BLACKMER,
FRANK J. GIFFORD,
Tellers.

After announcing the names of the newly elected officers, the retiring President, Mr. Metcalf, said:

In yielding the gavel to my successor I want to express to all of you the pleasure which it has given me to serve you this year, in so far as it has been possible for me to do so, being, as I was, across the Continent the greater part of the time when I should have been in this part of the country. On the other hand, I can do no more for Mr. Sullivan than to bespeak for him the same sort of cordial support and assistance which I have had during my term of office. Mr. Sullivan, as you know, was from 1887 to 1906 in the Water Department at Lowell; then he went to Nashua to take up the work there of guiding the destinies of the Pennichuck Water Works. He was elected a member of this Association on St. Valentine's Day in 1900. He has contributed, as you well know, important papers and has taken a very active interest in the affairs of the Association, serving on many important committees. He came to you, gentlemen, as a Valentine gift; he comes to the presidency in leap year. The signs augur well for a successful administration. In presenting him to you I only want to call his attention to what he faces on the membership

proposition; but for his comfort let it be said that if your retiring president, though absent so much, has been able to witness the increase in membership which has taken place, there is no telling what our new president can do as a " Johnny-on-the-spot." Gentlemen, I present to you Mr. Sullivan. [*Applause.*]

PRESIDENT SULLIVAN. *Mr. President and Members of the New England Water Works Association,* — It is an honor, a great honor, to be elected President of this Association, and I fully appreciate it. I also realize the responsibilities. I share the honors and the responsibilities with the other officers who have been elected, and I feel safe in saying that the officers and the Executive Committee will work with one end in view, and that is for the continued success of this Association. To do this we need your support and your coöperation. We want you to maintain the popularity of these meetings; we want you to popularize all gatherings of the New England Water Works Association. To-day the outgoing administration turns over to the incoming administration an organization of almost one thousand members. Think of it, one thousand members! Could that little band of pioneers, away back in the early eighties — and I might say that it is a pleasure for us all to see some of those early members here to-day — could they have thought how well they builded? Could they have dreamed of such an organization as this? It is the earnest desire of the officers and myself that you continue the popularity of these meetings. We have these monthly gatherings, and it is a time when we may get together to meet and greet one another, rub elbows with one another, — as it were, — exchange ideas, discuss problems and listen to high-grade papers; and not the least of a member's privilege is that he may discuss the papers. For it is by means of a free discussion that our members will be able to get information not easily obtained in any other way.

With this splendid membership as a legacy, how are we to fill up the gaps occasioned by the natural losses in membership? How are we to obtain new members? We know there are many men in the water-works business and in the engineering profession who are not availing themselves of the benefits of this Association. How many members are there of your water boards, directors, commissioners, of your office, engineering and station forces, who

ought to be members, not only to swell the membership of this Association, but for their own benefit? They would profit by coming to these meetings and listening to the papers, and it goes without saying they would be the gainers by reading the JOURNAL.

The President says I was elected a member of this Association on St. Valentine's Day. I will take his word for that. There are different kinds of valentines. Years ago, about the time I was elected, the comic valentine was very much in evidence.

As for this being leap year, I am a hopeless case. I have been roped and tied for some time. The hour is getting late, and I am not going to make any extended remarks, but I would like to say this in reply to the retiring President's remark of my being "Johnny-on-the-Spot": I do not know whether there is anything in our constitution which provides for a recall, but let me tell you it will be just as severe a shock to me if I get a "call down" as to get a recall. So I am going to make the effort to have our membership reach the one thousand mark, and I ask you all to assist me. Let our slogan be, "One thousand members or more." Let us keep up the good work, begun so many years ago. Let us keep this organization where it always has been and where the retiring President leaves it to-day, in the very forefront of such associations.

Again thanking you for the honor which you have conferred upon me, I wish you all a Happy New Year and I bespeak for the officers and for myself that you make this a popular and prosperous year for the New England Water Works Association.

HOTEL BRUNSWICK,
BOSTON, February 9, 1916.

The February meeting of the Association was held at the Hotel Brunswick, Copley Square, Boston, Wednesday, February 9, 1916, President Sullivan presiding.

The following members and guests were present:

HONORARY MEMBERS.

E. C. Brooks, A. S. Glover, F. E. Hall, F. P. Stearns. — 4.

MEMBERS.

C. L. Baker, L. M. Bancroft, A. E. Blackmer, J. W. Blackmer, C. W. Bowker, J. C. Chase, H. W. Clark, R. L. Cochran, F. L. Cole, J. E. Conley, John Cullen, A. O. Doane, John Doyle, E. D. Eldredge, G. H. Finneran, F. F. Forbes, F. L. Fuller, Patrick Gear, F. J. Gifford, H. J. Goodale, R. K. Hale, A. R. Hathaway, T. G. Hazard, Jr., D. A. Heffernan, A. C. Howes, E. F. Hughes, J. L. Hyde, C. E. Johnson, W. S. Johnson, Willard Kent, G. A. King, Horace Kingman, J. L. Kirkpatrick, E. J. Looney, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, H. A. Miller, J. W. Murphy, William Naylor, H. G. Pillsbury, L. C. Robinson, H. W. Sanderson, C. M. Saville, A. R. Sawyer, M. R. Scharff, J. E. Sheldon, C. W. Sherman, E. C. Sherman, H. L. Sherman, H. M. Sinclair, J. W. Smith, Sidney Smith, W. F. Sullivan, C. N. Taylor, A. H. Tillson, D. N. Tower, C. H. Tuttle, W. H. Vaughn, R. S. Weston, J. C. Whitney, F. I. Winslow, I. S. Wood, L. C. Wright. — 66.

ASSOCIATES.

Harold L. Bond Co., G. S. Hedge; Builders Iron Foundry, A. B. Coulters; Central Foundry Co., W. H. Feltt; Chapman Valve Mfg. Co., J. T. Mulgrew; Eddy Valve Co., H. W. Dotten; Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., J. H. Smith, A. S. Glover, and W. A. Hersey; Lead Lined Iron Pipe Co., T. E. Dwyer; Ludlow Valve Mfg. Co., A. R. Taylor; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., H. L. Weston and J. G. Lufkin; Neptune Meter Co., H. H. Kinsey; Pittsburgh Meter Co., J. N. Turner; Rensselaer Valve Co., C. L. Brown; A. P. Smith Mfg. Co., F. L. Northrup; Standard Cast Iron Pipe and Foundry Co., W. F. Woodburn; Thomson Meter Co., E. M. Shedd; Union Water Meter Co., F. E. Hall; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, E. P. Howard and Samuel Harrison; Warren Foundry & Machine Co., J. H. Morrison. — 27.

GUESTS.

J. H. Fields, Jr., Nashua, N. H.; D. H. Henderson, Cambridge, Mass.; H. G. Porter, H. W. Coombs, O. Z. E. Charest, H. W. Storrs, Boston, Mass.—6.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

Resident: Arthur W. Beckford, Danvers, Mass., water commissioner; Charles W. Bowker, South Paris, Me., superintendent and chief engineer; J. Frank Ellis, Rochester, N. H., water and sewer construction; George H. Leland, Providence, R. I., waterworks design and construction; Fred H. White, South Easton, Mass., water commissioner and superintendent.

Non-resident: Walo von Greyerz, Stockholm, Sweden, chief engineer; A. P. Learned, Kansas City, Mo., civil engineer; Maurice R. Scharff, Pittsburgh, Pa., general sanitary and hydraulic engineering practice.

Associate: Warren Foundry and Machine Company, 11 Broadway, N. Y., cast-iron pipe and fittings.

On motion duly made, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

The Secretary read the following recommendation from the Executive Committee:

"FEBRUARY 7, 1916.

"A grading scale for cities and towns has very recently been proposed by the committee on fire protection of the National Board of Fire Underwriters. With a view to safeguarding the interests of city water-works departments and private water-works owners, it seems very desirable that some action should be taken by this Association to approach this matter from the standpoint of the utility. In order to bring this matter before the Association the Executive Committee of this Association recommend that a committee of five be appointed by the chair to confer with the engineers of the National Board of Fire Underwriters before the standard grading schedule is finally adopted."

MR. CHARLES W. SHERMAN. Mr. President, I have been fortunate enough to secure from the National Board of Underwriters a copy of their proposed schedule. In order that the members may understand what we are talking about, perhaps I would better elaborate a little. For quite a number of years some of us have been trying from time to time to find out from the underwriters what changes in insurance rates would result from the construction or improvement of water-works systems, and we have never been able to get very much satisfaction out of it. Now the National Board of Underwriters have started to prepare a standard grading system, on the basis of which they will fix a certain standard for what they consider perfect protection, and take off a certain number of points for deficiency in certain lines. That applies not only to water works, but to fire departments, police, and the rest; but the water-works part of it interests

us very much. I prepared this vote before hearing that the Executive Committee were interested. I move

"That the President be authorized to appoint a committee of five members, to be known as the Committee on Grading Water Works for Fire Protection, who shall consider the 'Proposed Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions,' and report to a future meeting of the Association whether or not it is desirable for the Association to endorse this or any similar schedule. The committee shall have authority to confer with the National Board of Fire Underwriters or its engineers or other representatives, and with any similar committee from the American Water Works Association, or any other body of water-works engineers, and may, if in its judgment it is wise to do so, render its report as a joint report with such other similar committees."

[The motion was duly seconded.]

MR. SAVILLE. I think there are two committees or associations that are interested in this classification. These are the New England Insurance Exchange, which, as I understand it, covers old line companies, and the Factory Mutual Bureau, which confines itself to a limited class of risks. I don't know whether the New England Mutual goes outside of New England or not, but I understand that the National Board of Underwriters covers the whole country. I think that any action that the Association would take should not be antagonistic to the local insurance bureaus, but rather endeavor to bring about harmony between the water-works interest on the one hand and the insurance interest on the other.

MR. SHERMAN. My personal correspondence has been with the National Board, or rather its chief engineer, Mr. Booth, and it is through him that I succeeded in getting a copy of the schedule that is prepared by the National Board.

MR. FULLER. I would like to know if the rates are not fixed by the local boards. I don't know what the National Board would have to do with fixing rates in New England.

MR. SAVILLE. I am not familiar with this except in a local way, but I do know the National Board of Underwriters have been active all through the country — in the larger cities, anyway — and have been trying out and testing water-works systems. I

presume they are intending to make up this schedule on the basis of their investigation.

MR. H. V. MACKSEY. If we are to appoint a committee to confer with the National Association of Fire Underwriters I would like to know upon what terms we are to go into the conference. Do we go on terms of equality? Do they want us? Are they going to ask our advice and accept our judgment? My limited experience, and that of some of my friends, has been that the fire underwriters undertake to tell those who buy fire insurance from them what they shall do and what they shall pay for it. They also undertake to pass judgment on various water departments and say what value they put on them without outside aid or assistance. It is a matter that affects their profits and the cost to the person who is buying the underwriting, and if we as representatives of water works and minor officials in cities go into conference and try to tell them what they shall do and how they shall rate various cities and various properties, I think they will give us short consideration. I do not see any reason why our name should be tacked on and why we should be a tail to their kite. If they want our advice and will accept our suggestions, if our vote will have any weight or authority with them, then we would have license to go into conference, but suppose a committee consisting of waterworks superintendents were to consent to the rating of cities, and their own cities should be rated low against their protest, well—there would be no brass band out to meet them when they arrived home.

MR. SHERMAN. This committee will be given power, according to this motion, if in its investigation it is thought wise, to confer with the National Board or with other committees. They are to report back to this Association, of course, and they are to report to us whether or not they think it is wise to endorse that or any similar schedule. I think the wording is safe.

[The motion was adopted.]

The President subsequently appointed the following committee: F. A. McInnes, C. M. Saville, H. V. Macksey, C. W. Sherman, and R. J. Thomas.

MR. SAVILLE. To bring another matter before the Association, I would like to move that the vote passed by the Executive Com-

mittee that the initiation fees be remitted to members and associates of the American Water Works Association applying for admission to the New England Water Works Association during the year 1916 be approved by this Association. That, I understand, is about the same motion that was made last year.

[The motion was seconded.]

PRESIDENT SULLIVAN. You have heard the motion. Is there anything to be said on it? It is extending the courtesy that has been granted by the American Water Works Association to the members of the New England Water Works Association. We are going to continue to give the members of the American Water Works Association who have not availed themselves of it the opportunity to join.

[The motion was adopted.]

MR. SHERMAN. Mr. President, I would like to take just a minute to make what may be called a progress report for the Committee on the Dexter Brackett Memorial. Contributions are coming in in good shape. The committee is now considering in a general way what shall be done about the design of a medal, and while they have not yet selected a designer, they are perhaps approaching the point of doing so. I have here to-day a sample medal that was prepared for the National Academy of Science, that is similar to the one we have in mind; also photographs of two or three other medals. I should be glad to show them after the meeting to any that are interested.

THE SECRETARY. The following letter from Mr. Edward C. Sherman was presented to the Executive Committee, and its recommendations met with their approval and it was voted that it be presented at this meeting of the Association.

JANUARY 31, 1916.

Dear Sir, — A few engineers who are interested in the welfare of the city of Boston and who consider the recent action of Mayor Curley in making wholesale removals in the Public Works Department to be a detriment to the city and a blow to the engineering profession, wish to raise funds to be used in presenting the cases of F. A. McInnes, Storrs L. Durkee, and Bliss W. Robinson before the courts to which they have been appealed following an unsatisfactory hearing before the Commissioner of Public Works.

The Good Government Association will bear the greater part of the expense, but an additional amount, estimated at from $300 to $600, will be needed.

If you desire to contribute to the funds, please notify me of the maximum amount which you would care to give. Then when it is known how much will be required, you will be assessed in the proportion which your maximum offer bears to the total amount subscribed. Do not send any money now.

A prompt reply will be appreciated so that we may know how much we may count upon. It will be considered confidential.

Yours very truly,

EDWARD C. SHERMAN.

PRESIDENT SULLIVAN. The communication is self-explanatory.

A paper by Robert B. Morse, chief engineer, Department of Health, Baltimore, Md., on "Progress of Water Sterilization in Maryland," was read, in Mr. Morse's absence, by Mr. Saville. The paper was discussed by Mr. Harry W. Clark, of Boston.

The Association then listened with much enjoyment to some songs by Mr. James E. Donnelly, of Lowell, Mr. Bradford having responded to an appeal for an accompanist.

The Association then took up the discussion of causes of explosions of domestic boilers, the discussion being opened by Mr. D. A. Heffernan, of Milton.

Mr. W. A. Bradford gave a demonstration of the operation of safety valves, and also discussed two bills introduced by him into the General Court.

The following gentlemen participated in the discussion: Mr. F. F. Forbes, of Brookline; Mr. Caldwell; Mr. Frank L. Fuller, of Boston; Mr. Edward D. Eldredge, of Onset, and others.

The remainder of the meeting was occupied with a discussion of the report of the Committee on Meter Rates.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., January 12, 1916.

Present: President Leonard Metcalf; James Burnie, Chas. W. Sherman, Caleb M. Saville, Wm. F. Sullivan, Edwin C. Brooks, Samuel E. Killam, Lewis M. Bancroft, Willard Kent.

Ten applications for membership in the Association were received and the several applicants were by unanimous vote recommended therefor, viz.:

Members: William G. Newhall, assistant superintendent Portland Water District, Portland, Me.; Raymond Walker, superintendent Water Company, Edgartown, Mass.; John P. Wentworth, assistant engineer, Metcalf & Eddy, Malden, Mass.; Joseph F. Ranger, Water Commissioner, Holyoke, Mass.; Fred B. Nelson, civil and hydraulic engineer, New York City, N. Y.; Edward G. Gushee, 2d assistant engineer, Bureau of Water, Philadelphia, Pa.; E. D. Bistline, secretary Water Company, Newport, Pa.; Edward Mayo Tolman, chief engineer State Department of Health, Charleston, W. Va.; James A. Steele, Jr., manager City Water Works, Vicksburg, Miss.; George Mitchell, water engineer office, Aberdeen, Scotland.

The question of advisability of action of the Association in the matter of appointing a committee on legislation was discussed, and Mr. Henry A. Symonds, present by invitation, expressed his views on the subject. On motion of Mr. Brooks, the matter was referred to the Executive Committee for the coming year.

The President presented the efficient report of Mr. Alfred D. Flinn, delegate of this Association to the Pan-American Congress, which was read and ordered placed on file.

President Metcalf presented a résumé of the work of the Association during the past year, and it was by unanimous vote adopted

as the report of the Executive Committee, to be presented at the meeting of the Association this day.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Wednesday, February 9, 1916, at 10.30 A.M.

Present: President William F. Sullivan, and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, F. J. Gifford, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

Voted, that the initiation fees be remitted to members and associates of the American Water Works Association applying for admission to the New England Water Works Association during the year 1916.

Voted, that the President appoint a committee on membership, to consist of the President, *ex officio*, and such other members of the Association as he desires.

Voted, on motion of Mr. King, that letter of Mr. E. C. Sherman, relative to discharge of engineers by mayor of Boston, be read at the meeting of Association this day.

Nine applications were received, eight for active and one for Associate membership as follows:

Charles W. Bowker, superintendent Village Corporation Water Works, South Paris, Me.; J. Frank Ellis, superintendent Water Works, Rochester, N. H.; Arthur W. Beckford, water commissioner, Danvers, Mass.; George H. Leland, Providence, R. I.; Fred H. White, superintendent South Easton and Eastondale Fire and Water District, So. Easton, Mass.; Walo von Greyerz, Stockholm, Sweden; A. P. Learned, engineer, Kansas City, Mo.; Maurice R. Scharff, engineer, Pittsburgh, Pa. Associate: Warren Foundry and Machine Company, New York, N. Y.; and they were by unanimous vote recommended therefor.

On motion of Mr. King, the Secretary was instructed to make

inquiry in regard to Albany, N. Y., as a place for holding the next annual convention.

On motion of Mr. Saville, the President was authorized to appoint a committee to confer with a Committee of the National Board of Fire Underwriters on proposed grading scale of insurance rates.

The certificate of renewal of Treasurer's bond for five thousand dollars, by the Massachusetts Bonding and Insurance Company, was presented and by vote approved.

Adjourned.

WILLARD KENT, *Secretary.*

Metcalf & Eddy

14 Beacon Street, Boston, Mass. — Harris Trust Building, Chicago, Ill.

WATER SUPPLY AND SEWERAGE

Design — Construction
Supervision — Management
Reports — Valuations

WILL J. SANDO

Consulting, Hydraulic, Efficiency and Organization Engineer. Specifications, plans, inspection and tests for water works, hydro-electric and high-pressure fire service pumping plants.

629 Wells Building
MILWAUKEE, WIS.

NICHOLAS S. HILL, Jr., and S. F. FERGUSON

Consulting Engineers, Water Supply and Sewage Disposal. Evaluations and Reports. Laboratory for Analysis of Water and Sewage and for Testing Cement, Sand, Coal, and Metals. Steam and Hydraulic Power Plants.

100 Williams Street, New York

WILLIAM R. CONARD

Assoc. Amer. Soc. C. E. — Assoc. Mem. Amer. Soc. M. E.

322 High St., Burlington, N. J.

Inspections and Tests of Materials

SOUTHERN OFFICE

Maison Blanche Bldg., New Orleans, La.

R. C. HUSTON, C.E., Special Representative

INDEX OF ADVERTISERS.

	PAGE.
Ashton Valve Co.	xv
Buffalo Meter Co.	ix
Builders Iron Foundry	xi
Chadwick-Boston Lead Co.	xxiv
Chapman Valve M'f'g Co.	xviii
Clark, H. W. Co.	xii
Coffin Valve Co.	xxv
Conard, Wm. R.	i
Dixon, Jos. Crucible Co.	xii
Donaldson Iron Co.	xxi
Eddy Valve Co.	xx
Engineering Record, The	xxviii
Fox, John & Co.	xxiii
Hayden, James F.	xii
Hays M'f'g Co.	xiii
Hersey M'f'g Co.	iv
Hill, Nicholas S., Jr., & S. F. Ferguson	i
Lead Lined Iron Pipe Co.	xxiii
Leadite Co.	xxvi
Lock Joint Pipe Co.	xxvii
Ludlow Valve M'f'g Co.	xvii
MacBee Cement-Lined Pipe Co.	xii
Metcalf & Eddy	i
Mueller, H. M'f'g Co.	xiv
National Meter Co.	ii, iii
National Water Main Cleaning Co.	xii
Neptune Meter Co.	vi
New York Continental Jewell Filtration Co.	xxi
Norwood Engineering Co.	xv
Pitometer Company	x
Pittsburg Meter Co.	vii
Rensselaer Valve Co.	xix
Ross Valve M'f'g Co.	xv
Sando, W. J.	i
Smith, The A. P. M'f'g Co.	xxiii
Smith, B. F. & Co.	xii

(Index continued on page xvii.)

Water Meters

FOR ALL WATER WORKS SERVICE

All Sizes, 5-8 to 60 inches

CROWN

EMPIRE

NASH

GEM

PREMIER

With the only reliable straight-reading register in the market

National Meter Company

84-86 CHAMBERS STREET

NEW YORK CITY

BOSTON 159 Franklin St. | CHICAGO 1223 Wabash Ave. | PITTSBURG 4 Smithfield St. | LOS ANGELES 411 So. Main St.

CINCINNATI 10 West Third St. | SAN FRANCISCO 681 Market St.

The NASH
GAS ENGINE and TRIPLEX PUMP

FOR
Town and Village Water Works and Pumping Service Generally

CAN BE ADAPTED FOR EITHER GAS OR GASOLENE

National Meter Company
84-86 CHAMBERS STREET, NEW YORK

BOSTON: 159 Franklin Street
PITTSBURG: 4 Smithfield Street
CINCINNATI: 10 West Third Street
CHICAGO: 1223 Wabash Ave.
SAN FRANCISCO: 681 Market Street
LOS ANGELES: 411 South Main Street

APPROVAL

HERSEY DETECTOR METER

The Hersey Detector Meter has been accepted for eleven years in 3", 4", 6", 8", 10" and 12" sizes without any restrictions or conditions of any kind by every Insurance Company, Stock and Mutual, doing business in the United States, and by the Water Departments and Water Companies in more than 500 Cities and Towns for use on over 3,000 Fire Services protecting nearly $2,000,000,000. worth of Insured Property.

HERSEY MANUFACTURING COMPANY

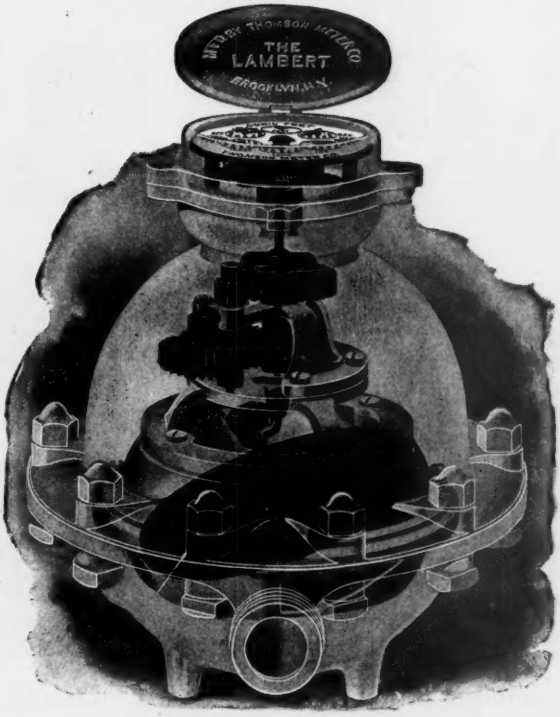
BOSTON	COLUMBUS, O.	SAN FRANCISCO
NEW YORK	PHILADELPHIA	LOS ANGELES
CHICAGO	ATLANTA	PORTLAND, ORE.

ACCURACY, LONG LIFE,

Avoidance of Repairs

Are the Requisites of the Perfect Water Meter and are the Principal Features of the

"LAMBERT."



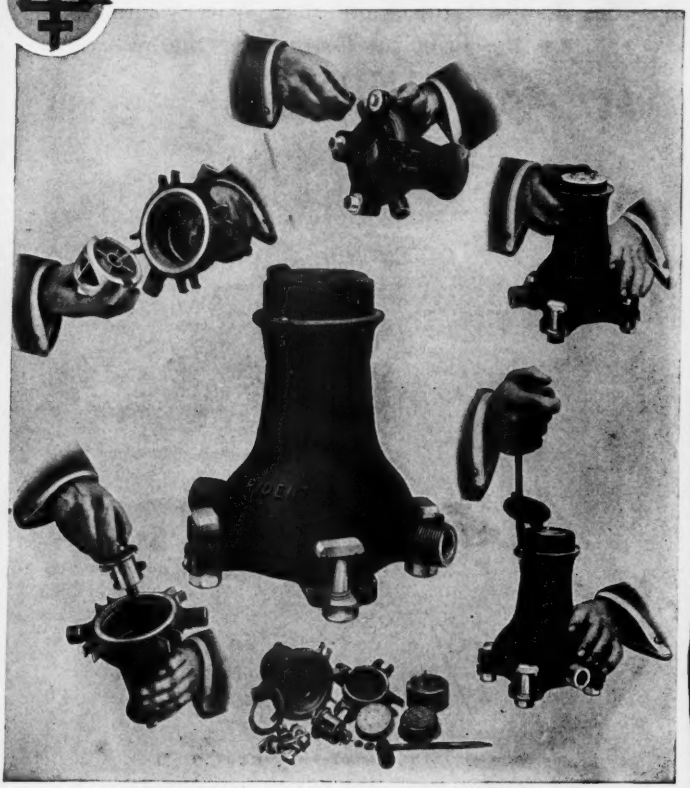
Our unbreakable disk-piston, reinforced with an internal steel plate, can be found only in the **LAMBERT METER.**

The growing popularity of the water-meter system is attributed by many to the inherent excellence of the **"LAMBERT"** meter. Where **"LAMBERT"** meters are selected, success is assured.

THOMSON METER CO.

100-110 BRIDGE ST.
BROOKLYN, N. Y.

TRIDENT WATER METERS



Assembling Simplicity of Trident Construction

The above cut shows a Trident-Disk Meter dismantled and the extreme ease with which it can be assembled, by first putting in the gear train, then the disk-chamber, the frost bottom next, then the register and register box and the meter is complete. The Trident combination wrench is the only tool necessary to use.

NEPTUNE METER COMPANY

90 WEST STREET NEW YORK

CHICAGO, BOSTON, SANFRANCISCO,
ATLANTA, LOSANGELES, PORTLAND, SEATTLE

"KEYSTONE" WATER METER

NEW YORK CHICAGO

Keystone and Eureka

Water Meters

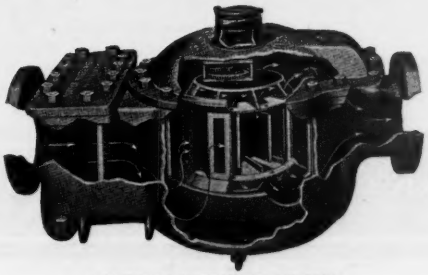
Pittsburgh Meter Co.

East Pittsburgh, Pa.

KANSAS CITY

COLUMBIA, S.C.

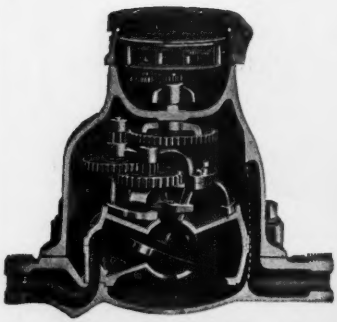
SEATTLE

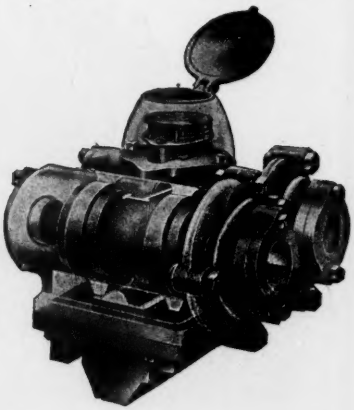


"EUREKA" WATER METER

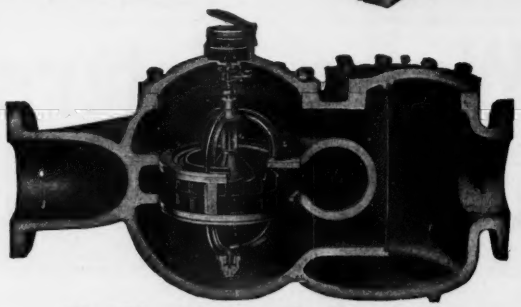
WORTHINGTON METERS

The Worthington Duplex Piston Meter is particularly adapted to large and heavy water works services.





The Worthington Disc Meter combines minimum weight with reliability on constant service and accuracy of registration.



The Worthington Turbine Meter
is designed primarily to handle large volumes of water with minimum loss of pressure.

Full descriptions of the different types of Worthington Meters, with tables of sizes and capacities, are given in Bulletin W184–54.

HENRY R. WORTHINGTON
WORKS, HARRISON, N. J. New York Office: 115 Broadway

Boston Office: 465 John Hancock Building

W159.8

Distributers for New England

GEO. E. GILCHRIST CO.

106 HIGH STREET

BOSTON, MASS.

UNION ROTARY, COLUMBIA, DISC and NILO (Velocity) WATER METERS

Water Pressure Regulators
Waste Stops and Corporations

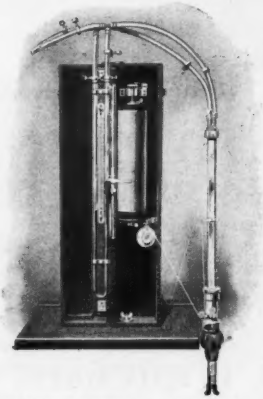
UNION WATER METER COMPANY
WORCESTER, MASSACHUSETTS

STOP THE UNDERGROUND WASTE OF WATER!

It is now known that UNDERGROUND leakage may be enormous. The PITOMETER is the most efficient Waste Meter known. Adopted by New York City, Washington, D. C., Chicago, St. Louis, Indianapolis, Pittsburgh, Memphis, etc.

PRISM
PHOTO RECORDERS
MANUAL RECORDERS
PUMP SLIP INDICATORS
STREET CONNECTIONS

The City of Washington, D. C., has found and stopped underground leakage amounting to over 30,000,000 gallons daily with our Pitometer. A saving worth $5,000,000 to the city.



The Pitometer is portable and will accurately indicate or record the flow of water in a pipe of any size, under any pressure, without cutting the main. Only a one-inch tap is needed.

We make water waste surveys for cities, or we sell or rent our instruments and help you to organize a Pitometer department of your own.

Write for Information

THE PITOMETER COMPANY, 25 Elm Street, New York

GLOBE SPECIALS

Approved and used by most water works in New England for the following reasons: Their spherical form offers the greatest possible resistance to bursting stresses

and permits, when necessary, the combination of an unusual number of branches on the same body without forming useless accumulations of metal.

The great majority of water works also use

VENTURI METERS

We make them

BUILDERS IRON FOUNDRY

PROVIDENCE, R. I.

H. W. CLARK CO.

122 South Seventeenth St., Mattoon, Illinois, U.S.A.

BRANCH OFFICES
NEW YORK SAN FRANCISCO CHICAGO
MANUFACTURERS

The Clark Meter Box — Meter Testers, Service and Valve Boxes, Valve Housings, and most everything for the Water Department.

Send for catalogues, prices, etc.

Member of the American and New England Water Works Associations
12 years inspecting materials for the Dept's of Water, G. & E. and Bridges of New York City

JAMES F. HAYDEN

INSPECTION AND TESTS OF MATERIALS
1601 45th Street, Brooklyn, N. Y. City

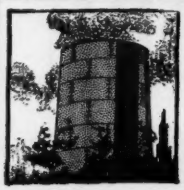
SPECIALTY:
Inspecting materials for high and low pressure water systems, gas conveyors, structural steel, and cast iron for buildings and bridges, railroad supplies

WM. F. WOODBURN

"STANDARD" CAST-IRON PIPE
SPECIAL CASTINGS
Estimates Free

TELEPHONE {Business Hours, 5951 Fort Hill
{Nights and Holidays, 957-W, Malden

201 Devonshire Street, Boston, Mass.
Works—Bristol, Penn.



Standpipes
Water Tanks
Gas Holders
and all other metal surfaces need the protection of
DIXON'S
Silica-Graphite
PAINT
BOOKLET NO. 87-S
JOSEPH DIXON CRUCIBLE CO. Jersey City, N. J.

C. D. Kirkpatrick S. P. Gates
Established 1878

B. F. SMITH & CO.

Incorporated

Artesian and Driven Wells, Foundation Borings

Engineers and Contractors for Municipal and Private Water Works

First National Bank Building
60 Federal Street Boston, Mass.

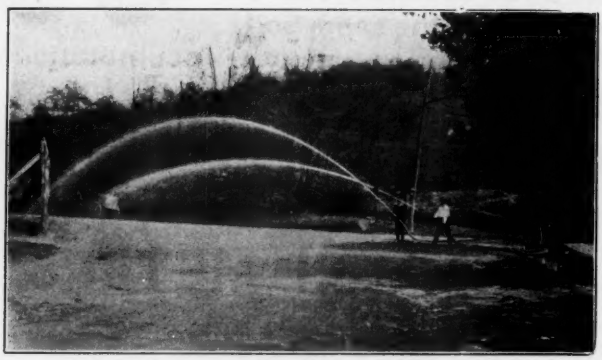
"CELLARWALL" SERVICES

3½ FEET LONG

SOMETHING NEW LAST LIFETIME

MacBee Cement Lined Pipe Co.
Boston, Mass.

?



?

ENOUGH WATER?

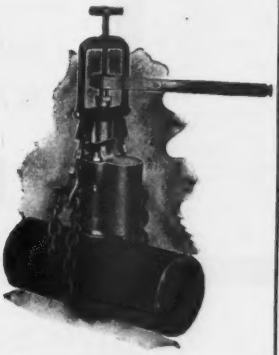
If not, it is probably because of lack of carrying capacity of your mains. Consult us.

Illustrated booklet upon request

NATIONAL WATER MAIN CLEANING CO.

50 Church Street New York City

Payne's Patent "NEW ECLIPSE" Tapping Machines

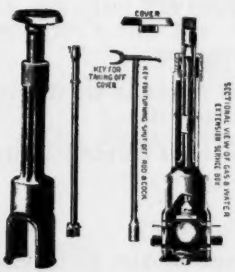


Do the best work, because they have

Few Working Parts
Compact
Simple in Construction
Light in Weight

We can prove these facts by sending a machine to you on thirty days' trial.

Long Main-End Corporation Cocks can be used



Makers of

High-Grade Water Works Brass Goods

to suit every requirement

Experience of hundreds of water companies has proven that original "HAYS-ERIE" SERVICE BOXES give the best satisfaction

Ask for Samples and Prices

Hays Manufacturing Co. Erie, Penna.

MUELLER
WATER TAPPING MACHINES

Mueller No. 2 Machine

Has your Company a MUELLER machine?

If not—why?

There isn't a better investment in the Water Works line.

One machine will last from 20 to 30 years; and with a very low cost of maintenance.

MUELLER machines are simple, efficient and convenient.

Every machine is Unconditionally Guaranteed.

Write us to-day for our booklet on tapping machines, and our liberal exchange proposition on your old machine, if you have one. Over 90% of the tapping machines in use in the United States are MUELLER machines.

H. MUELLER MFG. CO.

DECATUR, ILL.

NEW YORK CITY
CHICAGO

SAN FRANCISCO
SARNIA, ONT.

WATER
FILTERS
REGULATORS
& ENGINES

We make **Pressure Regulating Valves** for all purposes, steam or water.

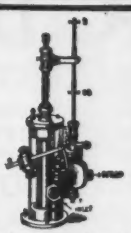
Our **Feed-Water Filter** will keep oil out of your boiler.

We can interest you if you use a condenser.

Water Engines for Pumping Organs

THE ROSS VALVE MFG. CO.

TROY, N. Y.



Standard for pumping church or parlor organs. Ask your organ builder for it or write us.

NORWOOD ENGINEERING CO.

FLORENCE, MASS.

MANUFACTURERS OF

"IMPROVED" WALKER FIRE HYDRANTS

ALSO THE OLD RELIABLE **"Holycke" Gate Hydrant**

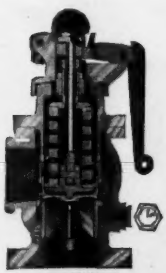
LICENSED MANUFACTURERS OF **The Vivian Rate Controller**

WRITE FOR CIRCULARS

We Want 1000 Members

Help Us Get Them

Use Application on Last Page of Advertisements



No. 20. Valve for Stationary Boilers.

They set the Pace

ASHTON POP VALVES and... STEAM GAGES

No. 74. Recording and Indicating Gage.

Superior in Quality of material and workmanship, and with greatest efficiency and durability, they challenge comparison with any others on the market. Send a trial order subject to approval ONLY IF SATISFACTORY, and thereby prove the claims made for them. HIGH GRADE GOODS OUR EXCLUSIVE SPECIALTY.

The ASHTON VALVE CO., 271 Franklin Street, BOSTON, MASS.

R. D. WOOD & CO.

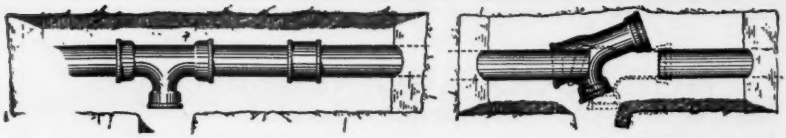
400 CHESTNUT STREET, PHILADELPHIA, PA.

Engineers, Iron Founders and Machinists

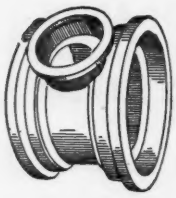
CENTRIFUGAL PUMPS
PUMPING ENGINES

Cast Iron Pipe

CUTTING-IN TEES



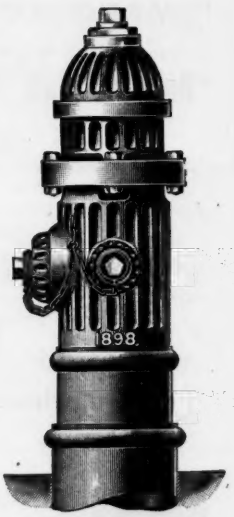
Old Way *Our Way*



Connections economically and easily made with one fitting. Saves sleeve, cuts, lead and unnecessary work and material.

"Reduced Specials"

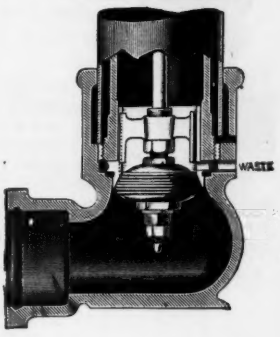
Cost of fittings reduced from 25% to 50%. Full strength. Deep bells. Convenient to handle. Sold by the piece.



Mathews Fire Hydrants

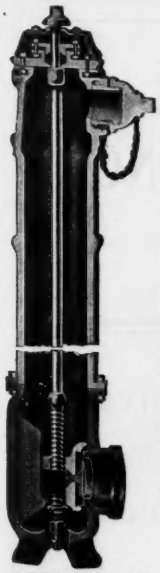
A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



Gate Valves

R. D. WOOD & CO. STANDARD
DOUBLE DISK
ANTI-FRICTION
EXTRA WEIGHT, FINISH
AND MATERIAL



THE LUDLOW VALVE MFG. CO.

MANUFACTURERS OF

VALVES and FIRE HYDRANTS

This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.

DOUBLE AND SINGLE GATE VALVES,

ALSO CHECK VALVES,

FOOT VALVES.

FIRE HYDRANTS.

YARD, WASH, AND FLUSH HYDRANTS.

☞ SEND FOR CIRCULARS. ☜

OFFICE AND WORKS: FOOT OF ADAMS STREET, TROY, N. Y.

BRANCH OFFICES:

NEW YORK	PHILADELPHIA	BOSTON	PITTSBURGH	CHICAGO	KANSAS CITY
82 GOLD ST.	HARRISON BLDG.	OLIVER BLDG.	1ST NAT. BANK BLDG.	THE ROOKERY	VICTOR BLDG.

INDEX OF ADVERTISERS (*Continued*).

	PAGE.
Thomson Meter Co.	v
Union Water Meter Co.	x
U. S. Cast Iron Pipe and Foundry Co.	xxii
Warren Foundry and Machine Co.	xix
Wood, R. D. & Co.	xvi
Woodburn, Wm. F.,	xii
Worthington, Henry R.	viii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS.

ARTESIAN AND DRIVEN WELLS.

B. F. Smith & Co. . . . xii

BRASS GOODS.

Hays M'f'g Co. . . . xiii
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii
Union Water Meter Co. . . . x

CAST IRON PIPE AND SPECIALS.

Builders Iron Foundry . . . xi
Donaldson Iron Co. . . . xxi
John Fox & Co. . . . xxiii
U. S. Cast Iron Pipe and Foundry Co. . . . xxii
Warren Foundry and Machine Co. . . . xix
R. D. Wood & Co. . . . xvi
Woodburn, Wm. F. . . . xii

CEMENT-LINED PIPE.

MacBee Cement-Lined Pipe Co. . . . xii

(*Index continued on page xxv.*)

THE CHAPMAN VALVE MANUFACTURING COMPANY

Manufacturers of

Gate Valves Drip Valves

Gate Fire Hydrants

Corporation Cocks Curb Cocks

Anderson Couplings

Lead Pipe Connections

Trade

Mark

WRITE FOR OUR WATER-WORKS CATALOG

Main Office and Works
Indian Orchard, Mass.

BRANCH HOUSES

BOSTON, MASS.	NEW YORK CITY	PHILADELPHIA	CHICAGO
141 High St.	180 Lafayette St.	1011 Filbert St.	116 N. Jefferson St.

The "COREY"
FIRE HYDRANT

MODERN
SUCCESSFUL
SIMPLE
DURABLE

SUPERIOR

RENSSELAER VALVES

ALL SIZES ALL PRESSURES

WATER, STEAM, GAS, OIL, ETC.

ELECTRICALLY OPERATED VALVES
Check Valves Air Valves
Indicator Posts Valve Boxes

CATALOGUE UPON APPLICATION

RENSSELAER VALVE CO., Troy, N. Y.

BRANCHES

NEW YORK, 180 Broadway PITTSBURG, 1102 House Bldg.
CHICAGO, 1108-9 Monadnock Block SEATTLE, 512 Colman Bldg.

ESTABLISHED 1856

WARREN FOUNDRY AND MACHINE CO.

Works at Phillipsburg, New Jersey
Sales Office, 11 Broadway, New York

Cast Iron Water and Gas **PIPE** From 3 to 60 inches in diameter

ALSO

All Sizes of Flanged Pipe and Special Castings

NEW ENGLAND REPRESENTATIVE

Messrs. F. A. HOUDLETTE & SON, Inc.

93 BROAD STREET, BOSTON, MASS.

EDDY VALVE CO.

WATERFORD, NEW YORK U.S.A.

PATENT RUBBER FACED

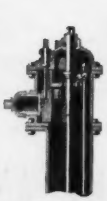
EDDY FIRE HYDRANT.

Section of Taper Seat Valve.

Section of Vertical Check Valve.

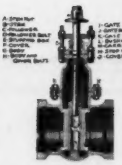
Horizontal Check Valve.

Hydrant with Water Crane Attachment.



Hydrant with Independent Nozzle Cut-off.

Indicator Post.



Section of Parallel Seat Valve.

Section of Vertical Foot Valve.

Vertical Foot Valve.

Water Crane with Automatic Drip Valve.

VALVE OPEN – DRIP CLOSED.

All Goods made by the EDDY VALVE COMPANY are manufactured exclusively at WATERFORD, N.Y., U.S.A.

VALVE CLOSED – DRIP OPEN.

GRAVITY AND PRESSURE FILTERS

HYPOCHLORITE STERILIZING APPARATUS

Over 350 Municipal Plants in Successful Operation

Total Daily Capacity 900,000,000 Gallons

THE NEW YORK CONTINENTAL JEWELL FILTRATION CO.

15 BROAD STREET NEW YORK
111 W. MONROE STREET CHICAGO
313 E. TENTH STREET KANSAS CITY
619 NEW BIRKS BLDG. MONTREAL

EMAUS PIPE FOUNDRY, DONALDSON IRON CO.,

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND ..

Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
Manhole Heads and Covers, etc.

EMAUS,
LEHIGH COUNTY, PA.

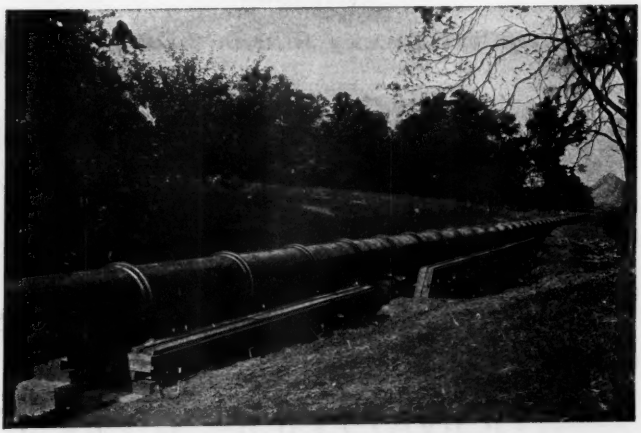
JOHN D. ORMROD, President,
J. G. EBERLEIN,
Secretary and Treasurer.

CAST IRON PIPE

ALL REGULAR SIZES, 3 INCHES TO 84 INCHES

FOR WATER, GAS, SEWERS, DRAINS, ETC.

SEND FOR STANDARD SPECIFICATIONS



RAILROAD AND TURNPIKE CULVERTS

FLANGE PIPE AND FLANGE FITTINGS

HEAVY CASTINGS

AND THOSE MADE FROM ORIGINAL DESIGNS

United States Cast Iron Pipe and Foundry Company

SALES OFFICES

71 Broadway, New York City.
1421 Chestnut Street, Philadelphia, Pa.
Henry W. Oliver Building, Pittsburgh, Pa.
122 South Michigan Boulevard, Chicago, Ill.
520 Security Building, St. Louis, Mo.
James Building, Chattanooga, Tenn.
799 Monadnock Building, San Francisco, Cal.
Northwestern Bank Building, Portland, Ore.

THE A. P. SMITH MANUFACTURING CO.

EAST ORANGE, N. J.

Manufacturers of

Tapping Machines, Fire Hydrants, Water Gates,
Economic Lead Furnaces,
Corporation and Curb Cocks, Brass and Aluminum Castings.
Also General Supplies for Water and Gas Works.

Write for Catalogue.

NICHOLAS ENGEL

JOHN FOX & CO.

CAST IRON
WATER & GAS PIPES
FLANGE PIPE

Special Castings, Fire Hydrants, Valves
General Foundry and Machine Work
253 BROADWAY - - NEW YORK CITY
Postal Telegraph Building

HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments
use
LEAD-LINED IRON and TIN-LINED PIPES
for their service connections

MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield ═══ Mass.

Chadwick-Boston Lead Co.

162 Congress St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable, but dangerous — **LEAD WOOL** may be employed to advantage. It makes perfectly tight joints to withstand the highest pressures, yet sufficiently elastic to admit of considerable sagging or settling of the pipe without causing the joint to leak. The difference in this respect, as compared with the poured joint, is notable.

NO FIRE — NO DANGER — NO TROUBLE.

Highest quality Lead Lined Iron Pipe and Fittings

Also **Pure Block-Tin Lined Iron Pipe and Fittings**

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder Pig Lead, White Lead and Red Lead

Coffin Valve Co.

BOSTON, MASS.

Manufacturers of Sluice Gates
Gate Valves
Check Valves
Flap Valves
Foot Valves
Fire Hydrants, etc.

SPECIAL ATTENTION PAID TO WATER-WORKS SUPPLIES FOR CITIES AND TOWNS

Send for Cuts and Prices of our
Type "B" Compression Hydrant and
Type "F" Gate Valves

Hydraulically and Electrically operated valves and sluice gates

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Continued*).

	PAGE.
CLEANING WATER MAINS.	
National Water Main Cleaning Co.	xii
FILTERS AND WATER SOFTENING PLANTS.	
New York Continental Jewell Filtration Co.	xxi
Norwood Engineering Co.	xv
Ross Valve M'f'g Co.	xv
FURNACES, ETC.	
H. Mueller Mfg. Co.	xiv
The A. P. Smith M'f'g Co.	xxiii
The Leadite Co.	xxvi
GAS ENGINES.	
National Meter Co.	iii
GATES, VALVES, AND HYDRANTS.	
Ashton Valve Co.	xv
Chapman Valve M'f'g Co.	xviii
Coffin Valve Co.	xxv
Eddy Valve Co.	xx
John Fox & Co.	xxiii
Ludlow Valve M'f'g Co.	xvii
Norwood Engineering Co.	xv
Rensselaer Valve Co.	xix
Ross Valve M'f'g Co.	xv
The A. P. Smith M'f'g Co.	xxiii
R. D. Wood & Co.	xvi
INSPECTION OF MATERIALS.	
Wm. R. Conard	i
J. F. Hayden	xii
LEAD AND PIPE.	
Chadwick-Boston Lead Co.	xxiv
Lead Lined Iron Pipe Co.	xxiii

(*Index continued on page xxix.*)

Twelve Reasons Why

YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
4. **LABOR SAVING.** Saves caulking charges and digging of large bell-holes, and reduces the cost of trench pumping to the minimum.
5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

WRITE FOR BOOKLET

THE LEADITE COMPANY, Inc.

LAND TITLE BUILDING PHILADELPHIA

84-inch Intake made for Public Service Corporation of New Jersey

MERIWETHER SYSTEM = REINFORCED CONCRETE PIPE

Used by

Large Manufacturing Companies and others, for Intakes, Outlets, Culverts, Air Flumes, Cable Conduits, Underground Passages.

Used by

States, Counties, Towns, Cities, for Sanitary and Storm Sewers, Water Lines, Culverts, Drains, Wells.

JUST THE PIPE YOU HAVE BEEN LOOKING FOR

LOW COST — Made in your own city

HIGH EFFICIENCY — Keep your money at home

LOCK JOINT PIPE COMPANY

165 Broadway — **New York City**

THE CANADIAN LOCK JOINT PIPE CO., Limited
Regina, Sask., Can.

PACIFIC LOCK JOINT PIPE CO.
Tacoma, Seattle, Wash.

The

Design and Construction

of

Water-Works Systems

and Novel Features in their
Management are given
careful attention by

THE

Engineering Record

It also gives prominence to the
following departments of a
Water-Works System:

DAMS
AQUEDUCTS
PUMPING STATIONS
PIPE SYSTEMS
WATER TOWERS
FILTERS

SAMPLE COPIES FREE

Subscription Price, $3.00 a Year

ENGINEERING RECORD

239 WEST 39TH STREET NEW YORK

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Concluded*).

PAGE.

LEADITE.
The Leadite Co. . . . xxvi

METERS.
Buffalo Meter Co. . . . ix
Builders Iron Foundry . . . xi
Hersey M'f'g Co. . . . iv
National Meter Co. . . . ii
Neptune Meter Co. . . . vi
Pitometer Co. . . . x
Pittsburg Meter Co. . . . vii
Thomson Meter Co. . . . v
Union Water Meter Co. . . . x
Henry R. Worthington . . . viii

METER BOXES.
Clark, H. W. Co. . . . xii
Hersey M'f'g Co. . . . iv

OIL, GREASE, ETC.
Jos. Dixon Crucible Co. . . . xii

PIPE JOINTS.
The Leadite Co. . . . xxvi

PRESSURE REGULATORS.
H. Mueller Mfg. Co. . . . xiv
Ross Valve M'f'g Co. . . . xv
Union Water Meter Co. . . . x

PUMPS AND PUMPING ENGINES.
Builders Iron Foundry . . . xi
National Meter Co. . . . iii
R. D. Wood & Co. . . . xvi

REINFORCED CONCRETE PIPE.
Lock Joint Pipe Co. . . . xxvii

TAPPING MACHINES.
Hays Mfg. Co. . . . xiii
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii

TOOLS AND SUPPLIES.
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii
Hays M'f'g Co . . . xiii
The Leadite Co. . . . xxvi

NOTICE.

The copies of the September, 1914, Journal have been entirely disposed of. Members who are willing to dispose of their copies will kindly mail them to the Secretary who will pay 75 cents a copy for a limited number. The following Journals are also wanted to make up sets: June, September and December, 1887; September, 1888; June, 1893; March and September, 1899; and September, 1905.

New Members!

Order your certificate of membership and the Association button Now.

New England Water Works Association

STANDARD SPECIFICATIONS

FOR

Cast Iron Pipe

AND

Special Castings

Price 10 Cents

Address, WILLARD KENT, *Secretary*
715 Tremont Temple
BOSTON, MASS.

WILLARD KENT, *Sec'y,*
715 Tremont Temple,
Boston, Mass.

Dear Sir:

Enclosed please find $\begin{matrix} \$\ .75 \\ 1.50 \\ 2.25 \end{matrix}$ in payment of charge for Certificate of Membership in the N. E. W. W. Association ($1.50), and Membership Button ($ .75), which please mail me and oblige

Yours truly,

_____

_____

New England Water Works Association,

ORGANIZED JUNE 12, 1882.

APPLICATION FOR MEMBERSHIP.

I, the undersigned, residing at .....

..... *being desirous of admission into the New England Water Works Association, hereby make application for* .....

(resident, non-resident or associate)

.....*membership.*

I am .....*years of age, and I have been engaged in the following named work:*

.....

.....

.....

I will conform to the requirements of membership if elected.

Signed, ...

Address, ...

Dated, ...*191*

Resident members are those residing in New England; all others are non-resident.
Entrance fee is $5.00 for resident and $3.00 for non-resident members.
Annual dues are $3.00 for both resident and non-resident members.

Endorsed by

.....

.....

Members N. E. W. W. Association.

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with verbatim reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness. ALL MEMBERS OF THE ASSOCIATION RECEIVE THE JOURNAL IN PART RETURN FOR THEIR ANNUAL DUES; to all others the subscription is three dollars per annum.

TO ADVERTISERS

THE attention of parties dealing in goods used by Water Departments is called to the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION as an advertising medium.

Its subscribers include the principal WATER WORKS ENGINEERS and CONTRACTORS in the United States. The paid circulation is OVER 900 COPIES.

Being filled with original matter of the greatest interest to Water Works officials, it is PRESERVED and constantly REFERRED TO BY THEM, and advertisers are thus more certain to REACH BUYERS than by any other means.

The JOURNAL is not published as a means of revenue, advertisements being inserted solely to help meet the large expense of publication.

ADVERTISING RATES.

One page, one year, four insertions	Sixty Dollars.
One-half page, one year, four insertions	Forty Dollars.
One-fourth page, one year, four insertions	Twenty-five Dollars.
One-twelfth page (card), one year, four insertions	Ten Dollars.
One page, single insertion	Thirty Dollars.
One-half page, single insertion	Twenty Dollars.
One-fourth page, single insertion	Fifteen Dollars.

Size of page, 7¾ x 4¾ net.

A sample copy will be sent on application.

For further information, address,

GEORGE A. KING,
Advertising Agent,
TAUNTON,
MASS.

Or, RICHARD K. HALE,
Editor,
85 Water Street, Boston, Mass.